High Tension Pole Line Construction

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

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THE JOURNAL OF ELECTRICITY, POWER AND GAS.

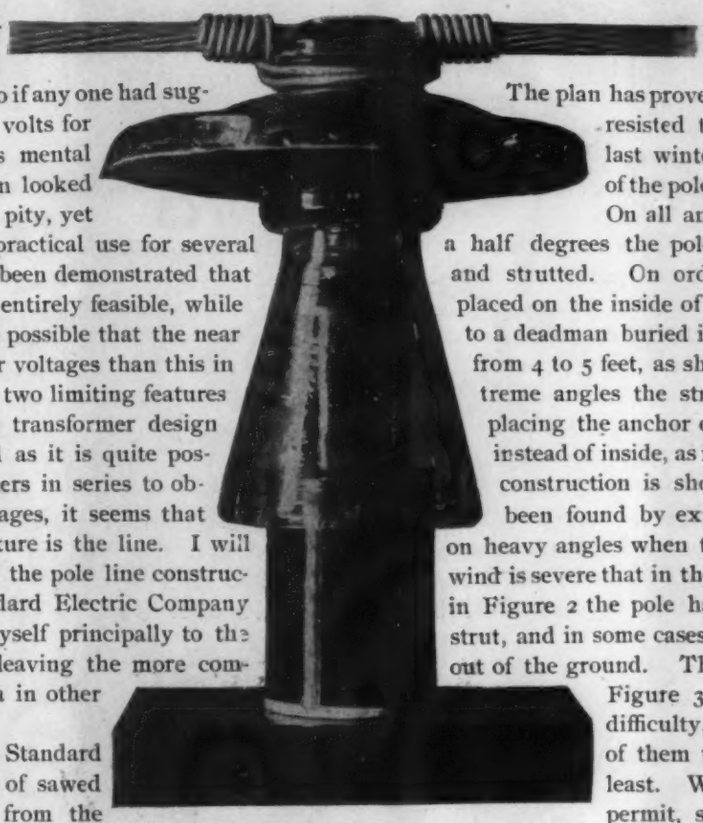
Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XI. SAN FRANCISCO, AUGUST, 1901. NUMBER 8.

*Some Details of High-Tension Pole Line Construction.**

BY C. O. POOLE.

STEP by step the natural power of our mountain streams has been brought closer to our factory doors—all through the energy and enterprise of our capitalists and the ingenuity of our engineers. The engineer makes this feasible and the capitalist converts the projects of the engineer into practical realization. Ten years ago if any one had suggested the use of 40,000 volts for a commercial purpose his mental condition would have been looked upon with suspicion and pity, yet this voltage has been in practical use for several years, and it has recently been demonstrated that the use of 60,000 volts is entirely feasible, while to my mind it seems quite possible that the near future will see even higher voltages than this in practical operation. The two limiting features in high-tension work are transformer design and line construction, and as it is quite possible to connect transformers in series to obtain extremely high voltages, it seems that the principal limiting feature is the line. I will give a brief description of the pole line construction adopted by the Standard Electric Company of California, confining myself principally to the mechanical construction, leaving the more complex electrical phenomena in other hands.



STANDARD INSULATOR, CABLE AND TIE.

The poles used by the Standard Electric Company are all of sawed redwood and are taken from the hearts of young trees. Not more than four poles are taken from any one tree, there being no sap whatever in the finished poles. The heights and sizes, together with the depths to which the poles are placed in the ground, are given in the table appearing on the following page.

In places where the ground is very soft and the tamping is not good the poles are set from 6 inches to one foot deeper than the depths given in the table. For crossing soft marsh land there is used what is termed a "bottom construction," which consists of a kind of maltese cross arrangement, made by spiking redwood pieces 2 inches by 8 inches by 8 feet long on all four sides of the pole, as shown in Figure 1. This construction is placed just below the ground, and a great weight of sod and earth is piled on top of it, reaching up the pole for a distance of about 3 feet. The plan has proven very satisfactory, having resisted the severe wind storms of last winter much better than some of the poles planted in firmer ground.

On all angles greater than two and a half degrees the poles are double constructed and strutted. On ordinary angles the strut is placed on the inside of the angle, and is fastened to a deadman buried in the ground to a depth of from 4 to 5 feet, as shown in Figure 2. On extreme angles the strut is used as an anchor, placing the anchor on the outside of the angle instead of inside, as in the previous case. This construction is shown in Figure 3. It has been found by experience in our work that on heavy angles when the ground is wet and the wind is severe that in the strut arrangement shown in Figure 2 the pole has a tendency to ride the strut, and in some cases the pole has been pulled out of the ground. The arrangement outlined in Figure 3, however, overcomes this difficulty, and I have yet to find one of them that has given away in the least. Wherever circumstances permit, severe angles are taken on two double constructed strutted poles, dividing the angle between the two poles.

For raising the poles we use a truck derrick, that is, a derrick mounted on the rear end of a low four-wheel truck, which is equipped with a windlass for controlling the position of the derrick. The truck is backed up to a position close to the pole and a sling is placed around it near the middle of the pole, to which the block is attached. The fall passes through a snatch-block fastened to the wheels of the truck and the horses walk out along the line, raising the pole in position to drop into the hole. In places where the truck cannot be taken the men pike-

*Submitted for discussion at the Fifth Annual Convention of the Pacific Coast Electric Transmission Association, San Jose, Cal., June 18-19, 1901.

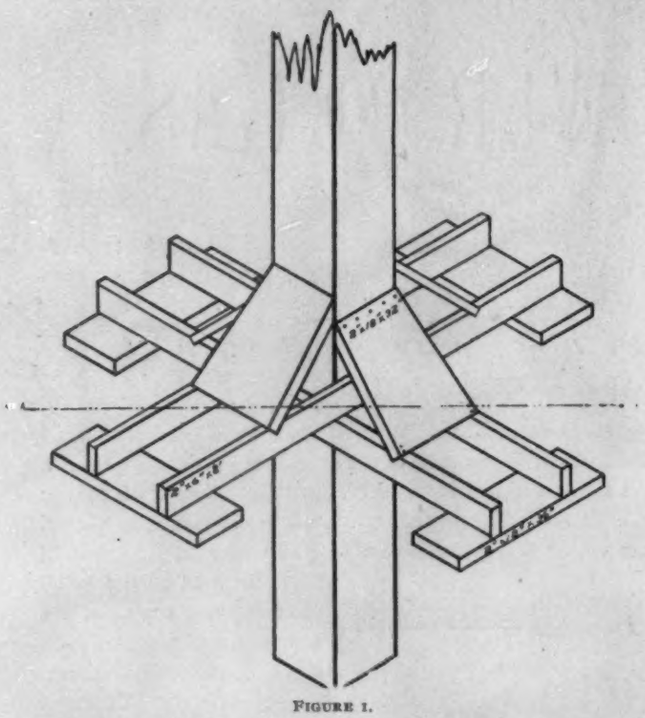


FIGURE 1.

in the small poles and use a gin pole for the larger ones.

On extremely bad ground where there is "no bottom," as the saying is, we have resorted to the use of piles, in some cases using one pile, in other cases two piles, and in one place where the line was forced out into the Bay of San Francisco, so to speak, three piles were used for supporting each pole. The three different methods are shown in Figure 4. This method of construction is rather expensive, but it offers the only solution for a difficult problem. The illustrations give two views of the three-pile bottom as erected.

HEIGHT AND SIZE OF POLES USED BY THE STANDARD ELECTRIC COMPANY.

HEIGHT.	TOP.	BUTT.	DEPTH IN GROUND.
30 feet	7x 7	12 x12	5 feet
35 feet	7x 7	13½x13½	5 feet 6 inches
40 feet	8x 8	13½x13½	6 feet
45 feet	9x 9	15 x15	6 feet 6 inches
50 feet	10x10	16 x16	7 feet
60 feet	11x11	17 x17	8 feet

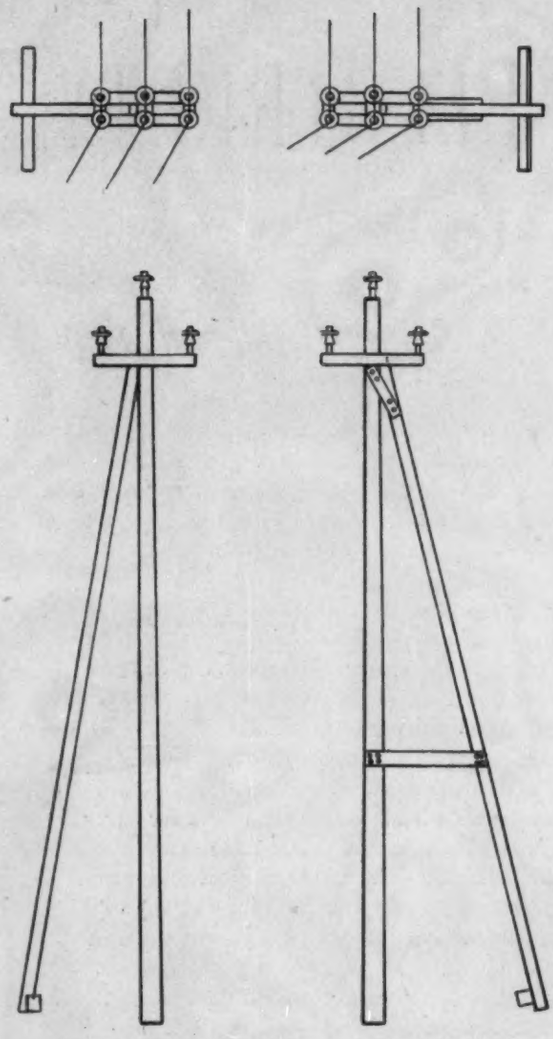


FIGURE 2.

FIGURE 3.

POLES ARE STRUTTED ON HEAVY CURVES.

THESE STRUTS ARE USED IN ORDINARY ANGLES.

Where the poles are supported over water, platforms 4 feet square are built around the bases of the poles at the top of the piles to facilitate line construction and repairs. These platforms are reached by a light board 10 feet long, which spans the distance between the platform and the railroad trestle, inside of which the poleline extends. Where the line crosses salt marsh lands, which are flooded by high tides, an elevated walk has been built for the patrolmen. The construction of this walk is shown in Figure 5, in which the 4x6 posts are driven into the ground at a distance of sixteen feet apart with a heavy maul. This distance is spanned with a foot plank, as shown in the figure, having 2 inch by 6 inch pieces spiked to its edges. The plank is sprung up in the center for a distance of about two and a half inches, thus making a truss of each plank. This construction has proven very satisfactory and is quite inexpensive to build.

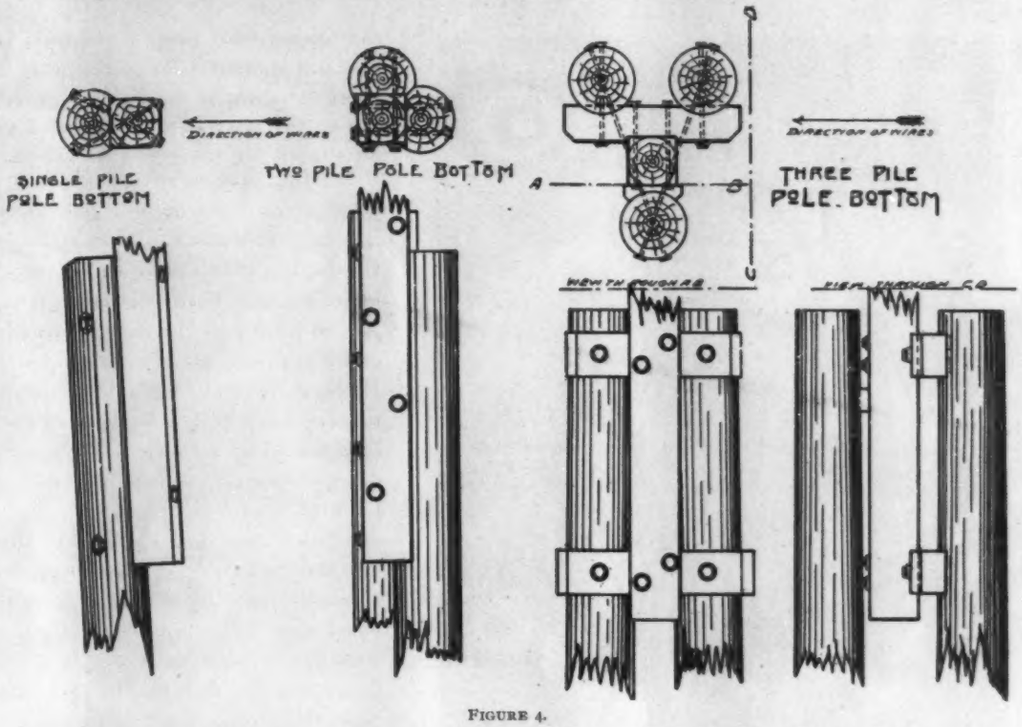
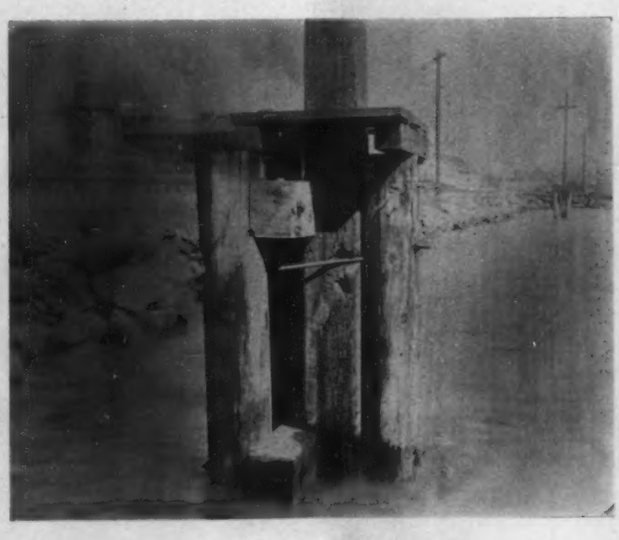


FIGURE 4.

There are several places where the Standard Electric Company's line crosses navigable streams. As the Government requires a clearance of not less than 115 feet above high water, we had to look to something other than poles to make the crossings. The longest span encountered was 618 feet, in which the sag in the line is 19 feet. Allowing 12 feet for a second line to be run later, makes the total height 146 feet. The method adopted for crossing these streams is shown in the photo-engraving on page 189. At this particular point there are three streams that require the 115-ft. clearance, and four steel towers were used to make the crossings. These towers are 150 feet high and are designed to carry two circuits of three wires each, one circuit being placed above the other. Figure 6 shows the construction of the tower tops, which are made of seasoned Oregon pine. As shown in the drawing, the cable strains are taken on four and six insulators. The crossarms (or rather the longitudinal arms in this case) are shaped to fit the curve of the ca-



THREE PILES ARE GENERALLY USED.

POLE-SUPPORTING PILES IN EAST OAKLAND.

PATROLMEN USE AN ELEVATED WALK OVER MARSH LANDS.

bles so as to divide the strain on the insulators. Some of the towers were compelled to take a horizontal angle, and in order to equalize the strain on the insulators and pins the arms were curved both vertically and horizontally, as shown on plan in Figure 6.

As the ground in the location of the towers is very soft, it was found necessary to use piles for foundations. The base of the tower is in the form of a quadrangle 25 feet square. Under each crossing are dr'ven four redwood piles 16 inches diameter at their butts. The four piles are driven as a solid cluster, securely bound together above ground with steel cables. The tops of the piles are sawed off on a slant to suit the batter of the tower members and capped with a cast-iron shoe bedded on a piece of sheet lead. A galvanized iron bolt 2 inches in diameter passes through the cap and down into each pile for a distance of about 4 feet, the nut and washer for the lower end being mortised into the pile. The detail of this work is shown in Figure 7, as well as in the accompanying halftone. As the cables leave the towers they drop to wooden take-offs, located about 550 feet distant from the towers. The construction of these take-offs is shown in Figure 8. The take-offs consist of two 40 foot poles strutted two ways with mudsills for supporting the struts and tying the frame together.

Having described the pole line from a ground man's point of view, let us now put on our spurs and see what is going on at the top of the pole. The old-time lineman climbs the pole as far as the telephone arm. Then he looks up and hesitates, and giving his spurs an extra jab into the pole, he throws his life belt around the pole and leans back, still looking up and soliloquizing: "Well, I'll be switched! I wonder if they've got a cable road up there. They've got a railroad tie for a crossarm, table legs for pins, a Chinaman's hat for an insulator, and a full-grown street railway cable for wire. That's too much for me!"

I think you will agree that the lineman is not very much to blame for his surprise, for the Standard line is certainly radically different from the pole lines of a few years ago. The line was designed to carry 60,000 volts with safety, and as a single circuit is to carry 10,000 horsepower a distance of 150 miles at less than 10 per cent. drop, the conductors must necessarily be large. This adds to the problem a mechanical difficulty not heretofore encountered.

The main line consists of three aluminum cables, each 7-8 of an inch in outside diameter and made up of 37 strands, having a total cross section of 471,034 circular mils. The weight per mile is 2404 pounds, and the resistance per mile is 0.205 ohms. This cable is all specially drawn and laid right and left hand. Its tensile strength of the cable is 28,000 pounds per square inch. In stringing the cable the deflections given were calculated for a maximum strain of 4000 pounds per square inch, giving a factor of safety of seven at 20 degrees F. The very high co-efficient of expansion of aluminum requires careful

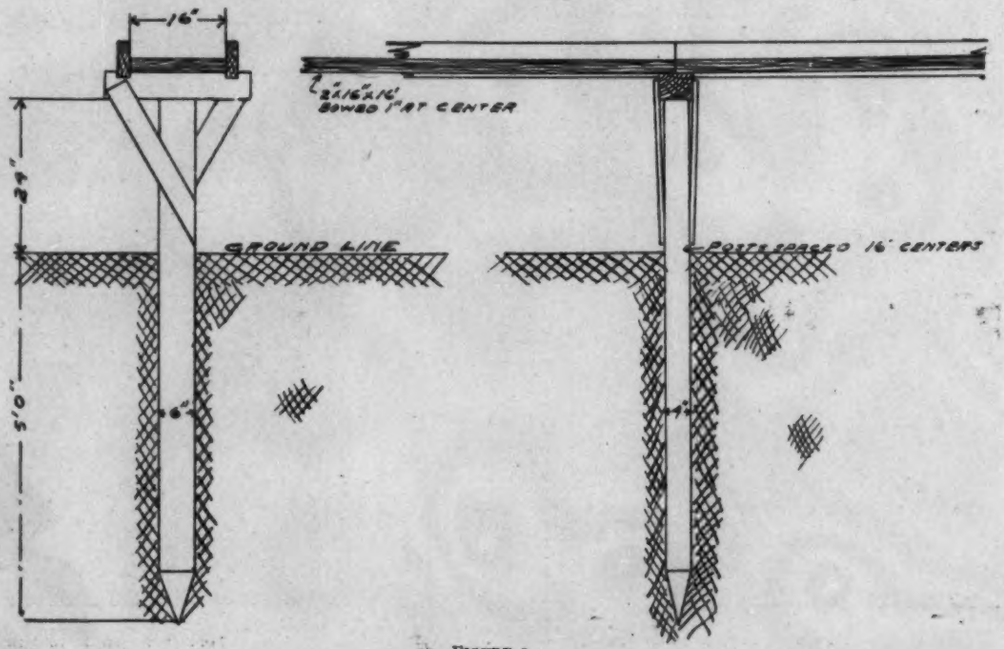


FIGURE 5.

consideration in stringing aluminum wire. The first impression one is likely to have of an aluminum line when seen on a hot day is that it is about time for the lineman to come along and cut out some slack, but if one sees the same line on a cold, frosty morning he will feel very much as though some lineman should cut in slack, instead of taking it out. A 132-foot span, having a deflection of 33 inches at 100 degrees, will have a sag of but 13 inches on a cold morning. Figure 9 is a table of deflections for different spans and temperatures, based on a mechanical strain of 4000 pounds per square inch at 20 degrees F. In this will be noticed the fact that there are two sets of temperature figures. The upper set I have called "mountain temperatures" and the lower set "valley temperatures." In the table the figures are simply shifted 10 degrees to the left, which gives about 8 per cent. less sag in the valleys, where the temperatures are less likely to reach the 20 degree mark.

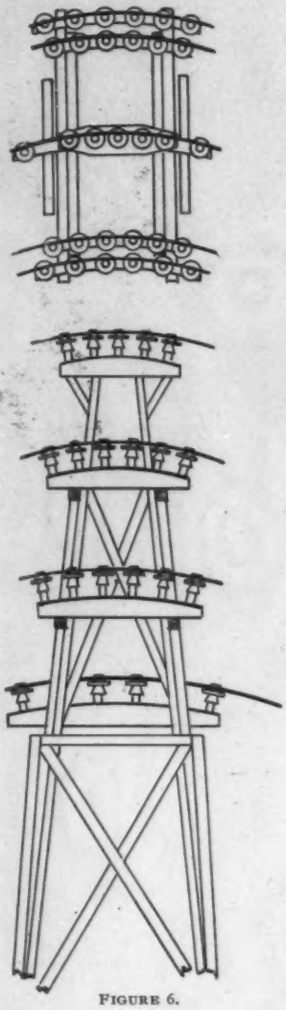
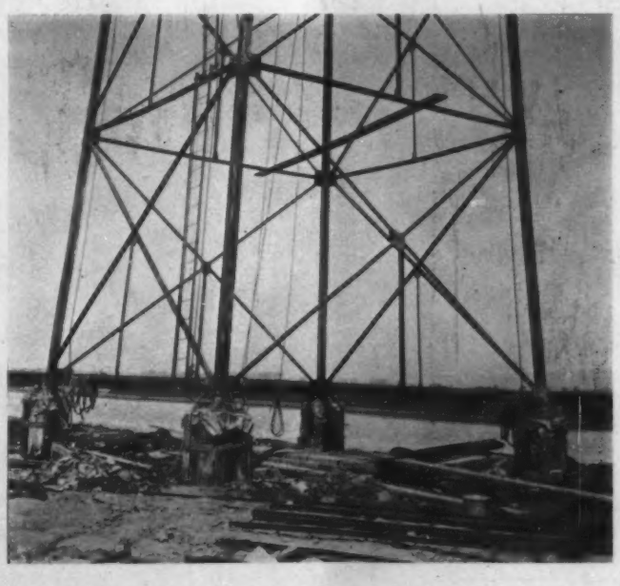
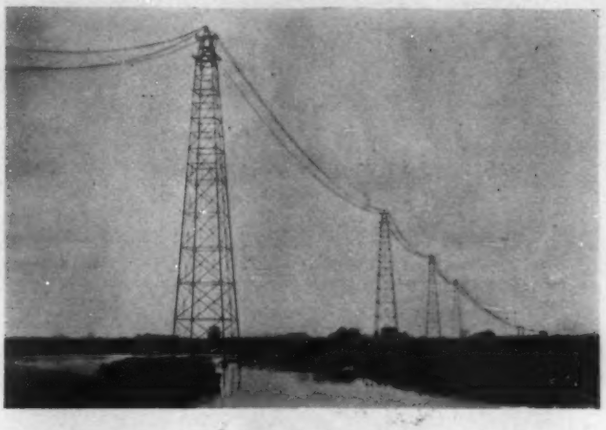


FIGURE 6.

It might be of some interest to know how the large cables are handled. The cable is shipped from the factory on hardwood reels, each reel containing a cable one mile in length. Wherever the ground would permit, the reel would be mounted on a stand and the reel-stand placed on the rear end of a low four-wheel truck. The team would then be driven out along the pole line, paying out the cable as the truck went along. A brake is used on the reel to steady the paying-out process. After the cable is laid out on the ground, the linemen, with hand ropes, haul it up on to the crossarm. On one section of the line a special two-wheel cart was used for paying out the cable, and it proved to be quite satisfactory. The



PILING SUPPORTS THE TOWER FRAMEWORK.



THE SAN JOAQUIN RIVER IS CROSSED OVER FOUR TOWERS.

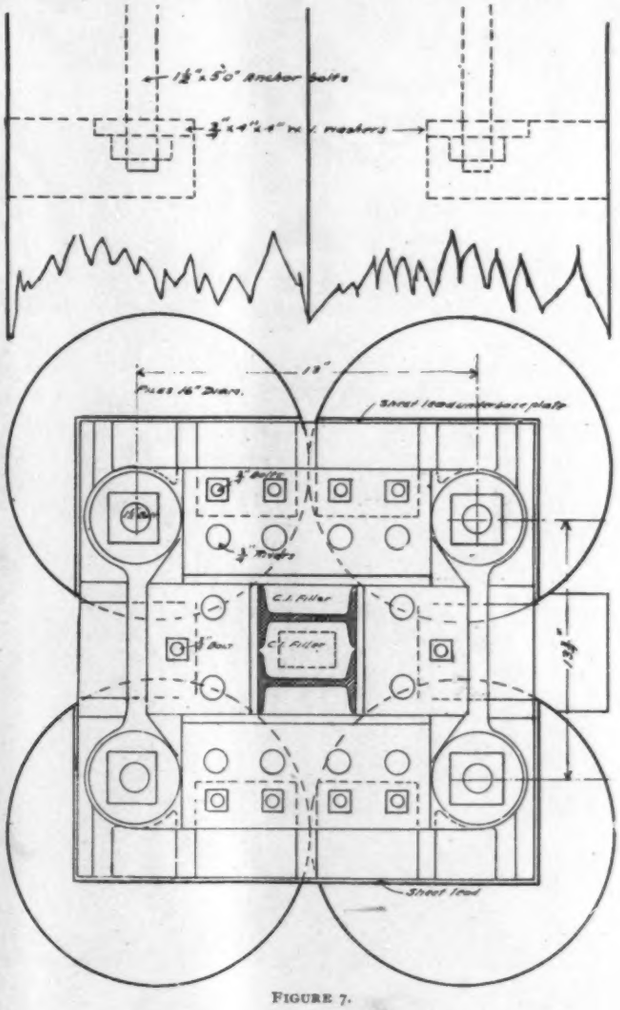


FIGURE 7.

THE LOW, FOUR-WHEELED TRUCK DERRICK.

THE TRUCK-DERRICK IN ACTION.

illustration gives an idea of the cart, which was so designed that the wheels could be taken off easily and the axle slipped through the center of the reel, using the axle for a reel-shaft.

In the rough mountain districts the men were forced to use the time-worn method of pulling out over the arms, sometimes using a team of horses for pulling the cable out, and at other times resorting to their good brawn in places where a goat could hardly find a foothold. Our plan of work is to lay out several miles of cable over the crossarms and then place the cable on the insulators. Each gang foreman is provided with a handy, accurate thermometer. Each lineman on the poles has a sighting target, which hangs from a cord that is knotted every two inches. These knots fit into a small brass hook, which is hung on the wire close to the insulator. The blocks and falls are then put on, one wire at a time, and from six to eight spans are pulled up at once. The foreman, after consulting his thermometer, gives the number of the knot to be placed on the hook, and the lineman on the crossarm sights from his target to his comrade's target on the next pole. When the slack of the line reaches the line of vision, he sings out and then ties in. This is repeated from pole to pole until the six

CABLE IS PAID OUT FROM A SPECIAL TWO-WHEEL REEL CART.

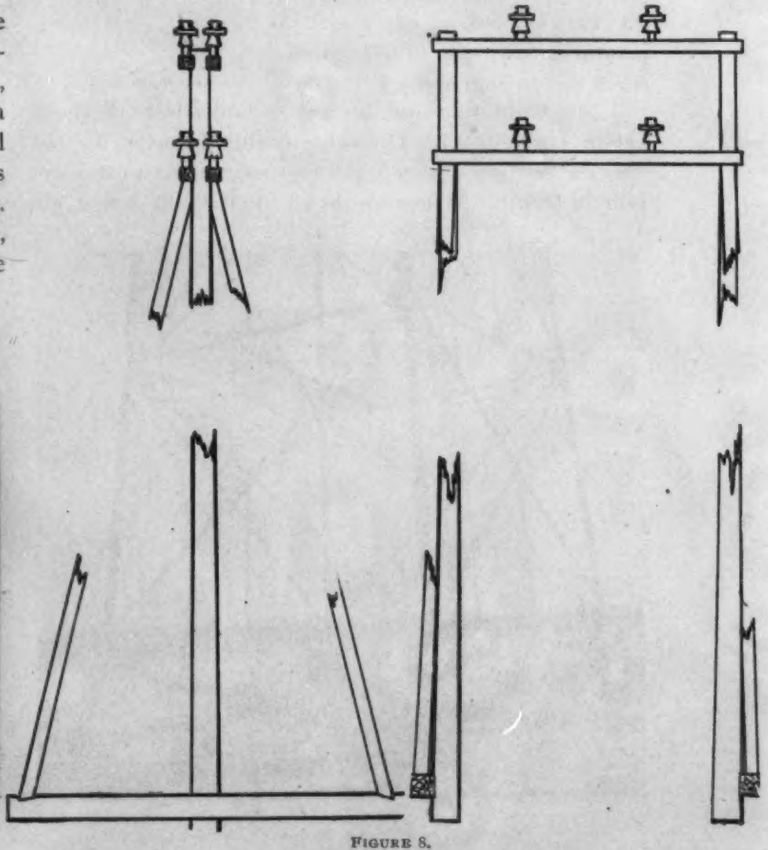


FIGURE 8.

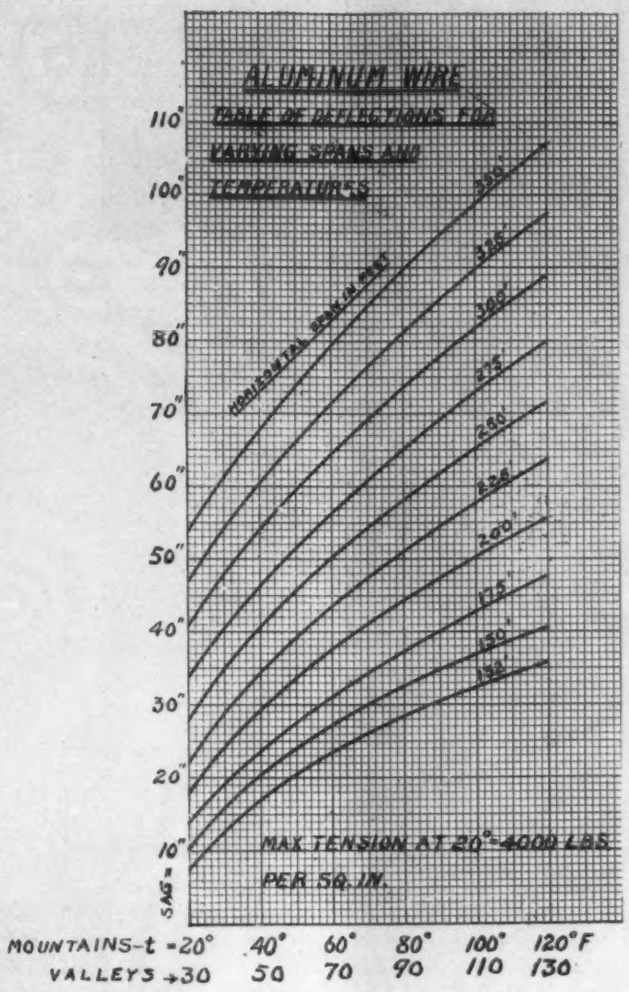


FIGURE 9.

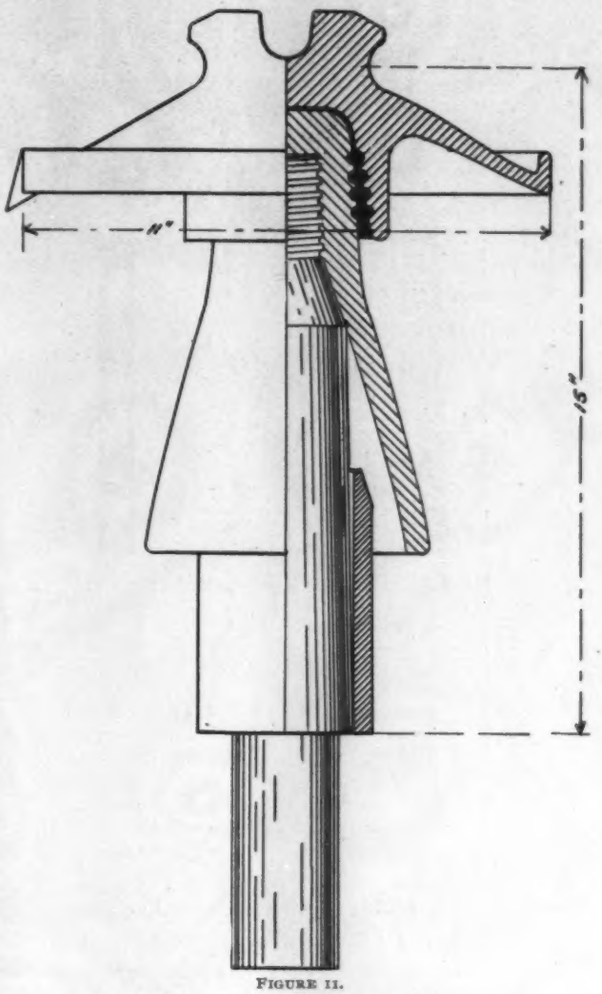


FIGURE 11.

spans are completed, when the blocks are moved ahead and made ready for another stretch.

The size of the wire used for tying the large cables is No. 1 solid aluminum, and for cables 1-2 inch in diameter and under, No. 4 aluminum is used. Our method of tying is somewhat different from any that I have seen in use, and we have found it to be very efficient. The line can be dead-ended at any pole, and the tie will hold the line without slipping. The initial engraving shows the method of tying. In very hilly sections where the line pitches up and down and the wire is thrown out of a true catenary curve, the table of deflections cannot be used. In such cases the foreman must use good judgment in allowing slack enough—the tendency is to be a little bit too economical with his wire. In several cases we have had to make more slack by raising or lowering poles, as we have preferred this method to cutting and splicing the cable. We also make a practice of allowing a little extra slack on bad corners, so as to ease them during cold snaps.

The method of joining cable is quite an important feature, and the final selection of the joint used was determined only after extended experiments. Figure 10

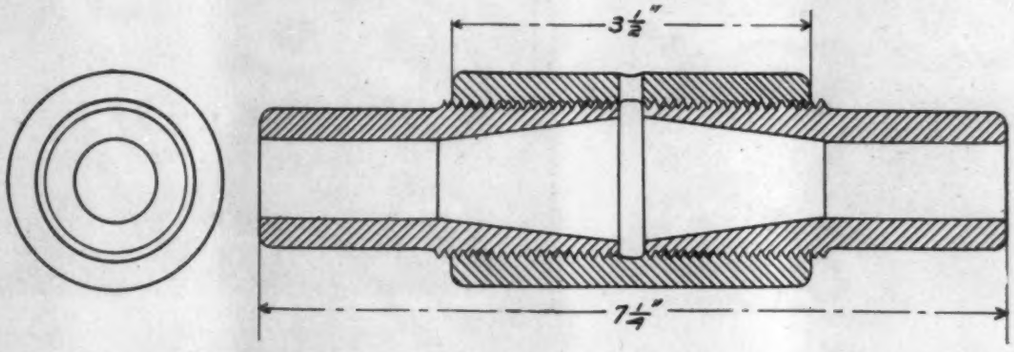


FIGURE 10.

FIGURE 12.

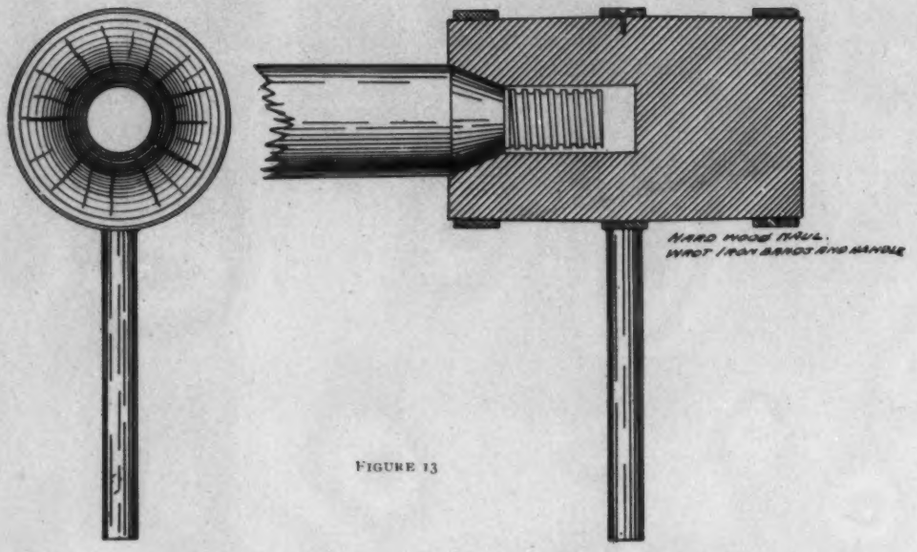


FIGURE 13

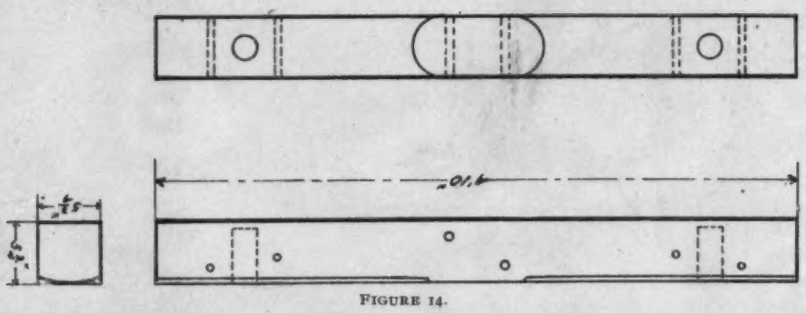
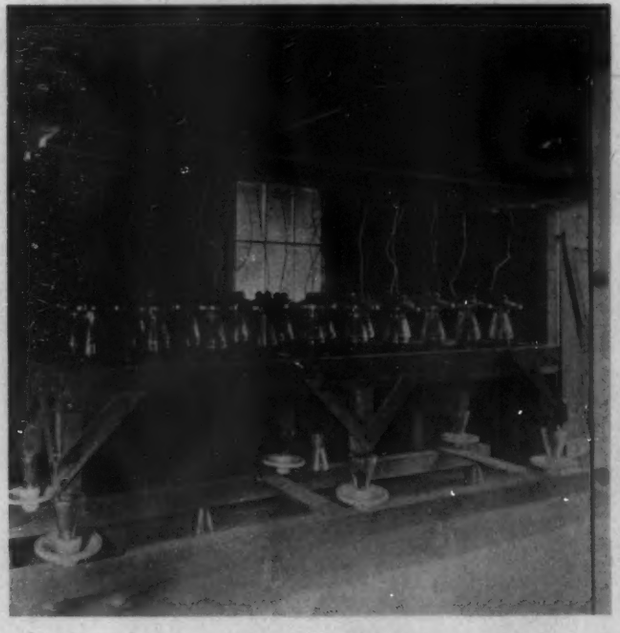
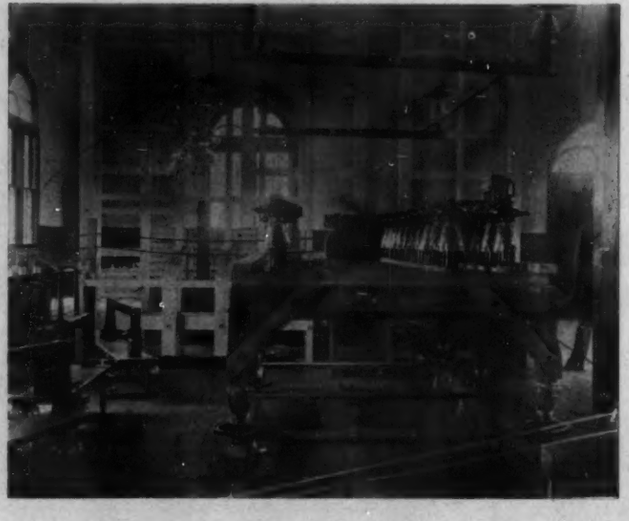


FIGURE 14.

shows this joint, and it may be added it has proven most satisfactory under most trying conditions. In testing the joint, the cable invariably broke just outside the joint before it would pull through. As will be seen from the cut, it is a right and left hand screw joint, in which the two male parts are cupped out large at the thread ends. The method of joining the cable is as follows: The cable is cut off square with a hack saw and the end passes through one of the male parts. About one inch of the ends of the cable strands are turned back upon themselves and the knot thus formed is forced back into the socket, when a small tapered aluminum plug is driven into the center of the knot, filling the socket completely. The other part is treated in the same manner, the nut is then screwed on, which draws the cable ends together



TESTING INSULATORS AT 130 000 VOLTS.



INSULATORS UNDER TEST AT THE GROVE STREET SUBSTATION SHOWED DARK FLASHES AT TIMES.

and makes a firm and solid joint. The resistance of the joint is less than the resistance of an equal length of the cable.

We now come to the most important of all the important features in high-tension transmission work—the insulator.

Without tiring you with the details of the development of the insulator that the Standard Electric Company is using, I will state briefly that at the time we adopted it there was nothing on the market that would anywhere near meet our requirements, hence it was not until after many months of cut and try methods had passed before we obtained an insulator that would stand the exacting test to which it would be subjected. Figure 11 shows the Standard insulator in section and perspective, and the initial illustration shows it as erected. It is what is called a two-part insulator, the upper part being of porcelain and the lower part of glass.

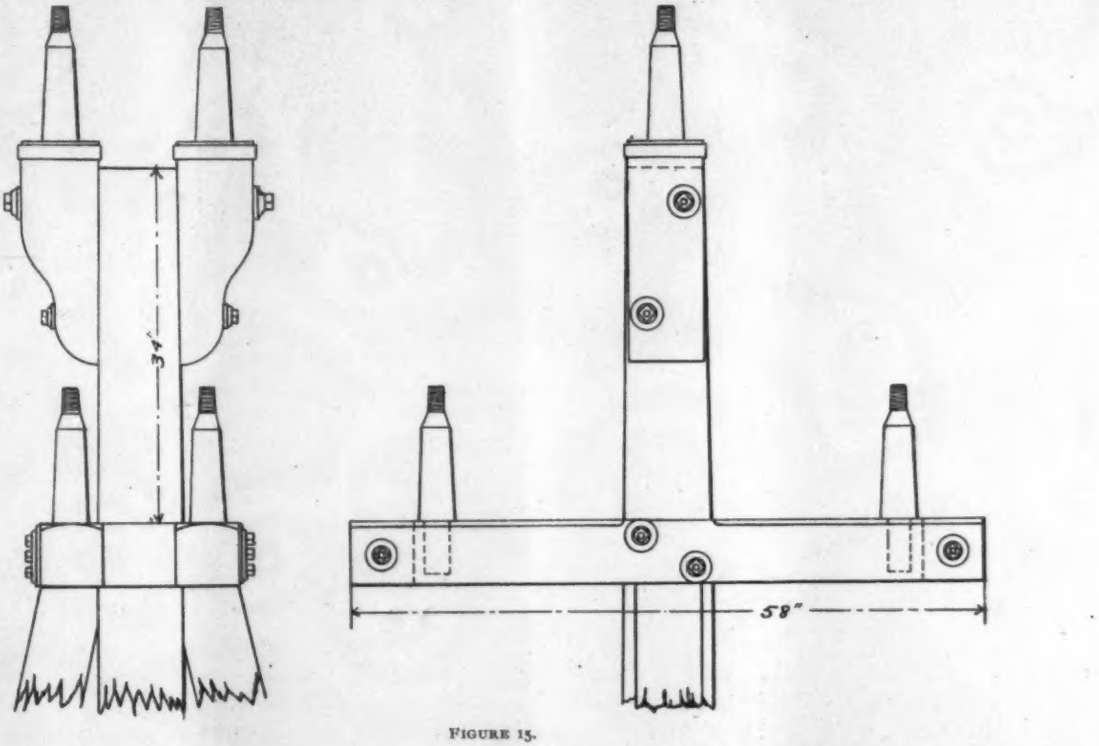


FIGURE 15.

There are several reasons why a combination insulator was decided upon. First, the dielectric strength of the glass is greater than an equal thickness of porcelain, while, on the other hand, moisture clings less readily to the porcelain. It was also found that a much cheaper insulator could be made in this way than making it either wholly of glass or of porcelain. As a matter fact, the insulator as designed could not be made of glass in one piece. The two parts of the insulator are cemented together with a cement composed of sulphur and sharp sand in about equal parts. After being cemented together, every insulator is subjected to a test of 120,000 volts for a period of five minutes, and if any insulator shows a sign of weakness it is rejected. In testing the insulators,* the pins upon which the insulators are mounted are hollow and a wire leads up through the pin, terminating in a spiral spring at the top of the pin. This spring projects about an inch above the top of the pin. The pin is capped with a piece of sheet copper, about one inch in diameter, to present a good contact surface for the insulator to rest upon. The insulators are then placed on the pins, resting upon the contact, which is one terminal of the testing set. For the other contact there is used a piece of No. 14 soft copper wire that is fastened tightly around the tie groove of the insulator in the form of a noose and slip knot. Thirty insulators are placed on the testing rack at one time; when the pressure is gradually brought up to approximately 120,000 volts, the spark gap being set at 12 1-2 inches. If an insulator gives away, it is replaced with another one and the pressure is applied again. This process is repeated until the nest of insulators stands the test for five minutes. It was found by experience that an insulator after standing the test for five minutes would seldom show signs of weakness when subjected to a longer exposure. This method of testing is very rapid, as two men will test thirty insulators in about fifteen minutes, or an average rate of one-half minute for each insulator. The high-voltaging set† consists of twelve transformers, each giving a pressure of 10,000 volts. The transformers are connected in groups of three on the low-tension side through insulating transformers, the high-pressure terminals being all

*The extraordinary photographic phenomenon of "dark" flashes is brought out in the illustration of the original testing set in a striking manner. When the potential approaches 120,000 volts, vivid sparks leap over from the contact on the tops of the insulators to their pins, and it is these sparks which, though of vivid brightness, are shown in the photo-engraving as being black.—C. O. P.

†For details, see THE JOURNAL for July, 1901, Volume XI, page 180, *et seq.*

connected in series. The pressure is regulated by a rheostat connected in series with the low-tension circuit.

The insulator pins used by the Standard Electric Company are made from eucalyptus, or blue gum wood, specially seasoned and treated as follows: The timber is sawed into sticks 3 inches square and placed in a vat of boiling water for twenty-four hours, when the sap becomes thoroughly boiled out, being displaced by the water. The timber is then racked up and air-dried for several months. The wood, after undergoing this treatment, is thoroughly seasoned and is tough and hard as hickory. The timber is then worked up into pins by a machine that completes the pin in one operation. The pins are then placed in a vat of boiled linseed oil, which is kept at a temperature of 210 degrees F. for several hours. The oil penetrates the pins to a depth of about 1-16 of an inch and makes a very good moisture-proof finish. Figure 12 gives the shape and dimensions of the pin. Its largest diameter is 2 3-4 inches, and it tapers to 2 1-2 inches at the upper shoulder. The diameter at the base of the thread is 1 1-2 inches and 1 3-8 inches at the top, the thread having a taper of 1-8 of an inch in 2 1-4 inches, the number of threads per inch being four. The shank of the pin is 2 1-4 by 4 7-8 inches, and the length of the pin over all is 16 7-8 inches.

Before the pin is driven into the arm, the shank is dipped into P. & B. paint, and some of the paint is put into the pinhole of the arm. A hardwood set is then placed on top of the pin, slipping down freely over the thread and resting upon the shoulder of the pin. An eight-pound sledge is then used to drive the pin home. This method of driving the pins into the arm has proven very satisfactory, for hardly ever has a pin been spoiled. Figure 13 shows the construction of this pin-driving tool. On the base of the pin is used a porcelain sleeve 5 inches long, which rests upon the crossarm and projects up beneath the glass petticoat. The object of this porcelain sleeve is to protect the pin in the event of an arc tending to strike from the eve of the insulator to the base of the pin. It also protects the pin from weathering.

The crossarms are made from selected close-grained and kiln-dried Oregon pine. After boring, the arms are treated with asphaltum oil by placing them in an enclosed boiler under pressure and subjecting them to a temperature, while in the oil, of about 250 degrees F. They are kept submerged in this oil for several hours until the wood is thoroughly permeated with the substance. Asphaltum oil has been found by experiment to be a very good insulator and it is also an excellent wood preservative. The dimensions of the crossarm are given in Figure 14. The distance between the pin holes is 42 inches and the arm is placed on the pole in such a position that the wires form the points of an equilateral triangle having 42-inch sides. The arm is gained into the pole one inch and is held on with two 5-8-inch through bolts with large cast iron washers. It will be noticed in Figure 15 that the pin holes are not bored through, for the reason that one inch of wood was left to add strength to the arm. Figure 15 gives a view of the pole top complete. The top of the pole is beveled off and an iron band 1-4 by 1 1-2 inches is driven on to prevent the pole from splitting. The pin is then driven in as was done in the arm.

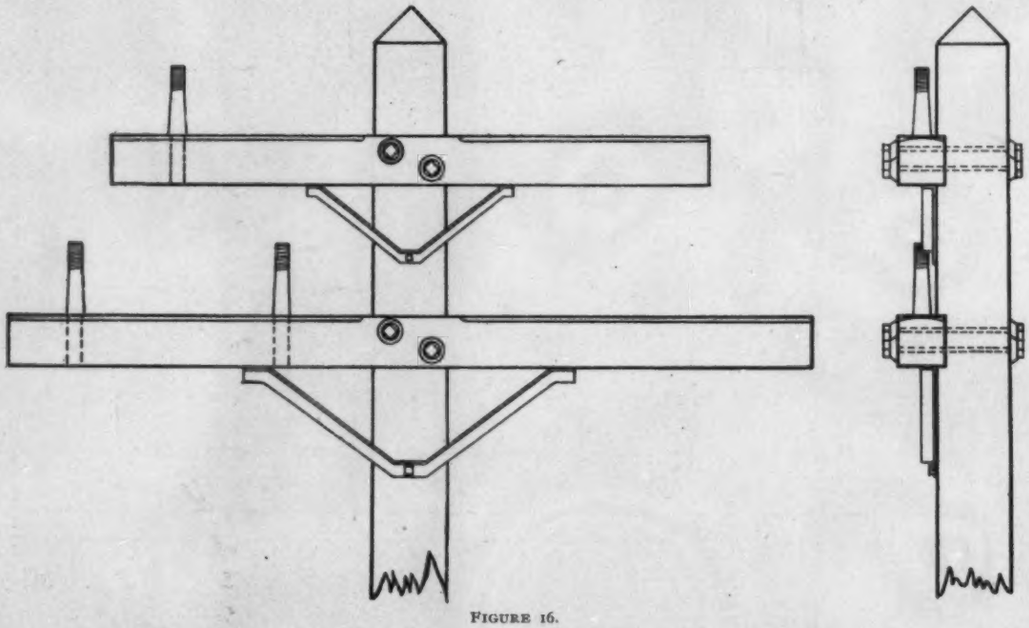


FIGURE 16.

Having designed the pole top and secured samples of crossarms, pins and insulators, we may next proceed to determine the weakest point in the combination. In testing, we fitted up a crossarm, pin and insulator complete and then bolted the arm securely to an iron column. A sling was next fastened around the tie groove of the insulator, and, with a dynamometer in circuit with a pull chain, we split the crossarm into pieces with a pull of 1200 pounds. Next a half-inch carriage bolt was put

through the arm at a point 3 inches from the center of the pin and 2 inches from the top of the arm, but when the pull was increased to 1800 pounds, the arm split toward the pole. Another 1-2-inch bolt was put through the arm the same distance from the pin toward the pole, but the test applied broke the pin off squarely at the shoulder on top of the arm, at a tension of 2200 pounds. These figures are not taken from a single test, but are the average of a series of tests. The cost of putting the four bolts in the arm, including the bolts, washers, boring holes and all labor in connection with it, did not exceed 10 cents per arm, and it fully doubled its strength. All poles carry a six-pin telephone arm placed 6 1-2 feet below the power arm.

The telephone line consists of a No. 8 B. & S. iron wire, which is transposed every four poles on a single transposition insulator. The power line is not transposed at all. Provisions are made for opening the power line at several points in case of trouble by means of switches in specially designed switch-houses.

Figure 16 shows a pole top that has been recently adopted for the 10,000-volt mountain circuits. This method of construction permits of two separate circuits being carried on the same pole in the form of an equilateral triangle, and either circuit can be safely handled while the other is hot.

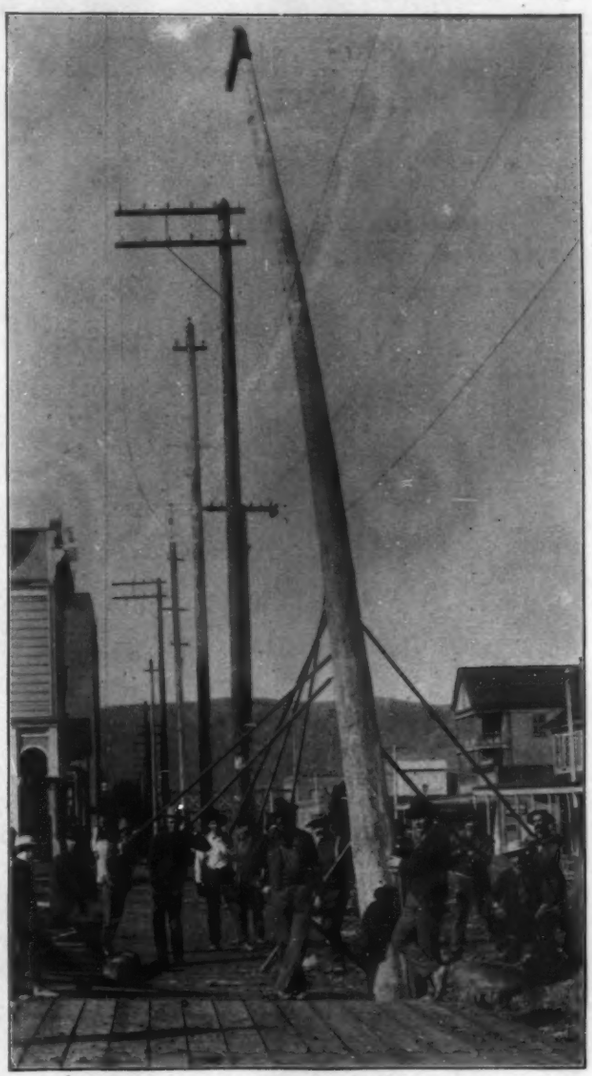
I am indebted to Mr. A. C. Bunker, the Stanley Electric Manufacturing Company's engineer, for the privilege of describing his design of pole tops. Mr. Bunker will be pleased, I know, to give any further information on the subject that I may have overlooked.

THE BAY COUNTIES TRANSMISSION LINE.*

BY C. E. DUTCHER.

AS the design, construction and installation of generators, transformers and motors has been brought to such a state of perfection as to guarantee absolutely continuous and successful operation at very high efficiencies, it has been the aim of the Bay Counties Power Company to bring its pole lines to an equally high degree of efficiency in every possible sense. For this reason it was decided to install a double pole line throughout the entire length of its bay line, from the power-house at Colgate to the city of Oakland, so that should one line go down from any cause, the service would still be continued uninterruptedly over the other line until repairs could be made. The company did not stop with a double pole line, however, in its endeavors to make the transmission link of its system the best that could possibly be devised, for throughout there has been selected and used only the best of material and workmanship in order to guarantee and insure uninterrupted service.

All poles are set one foot deeper in the ground on angles. The poles are shaved the entire surface of the top to a point six inches below the bottom cross arm, and are painted with a tar paint put on hot, which gives it the glossy finish that is the identifying characteristic of the Bay Counties lines. The butts are saturated with hot carbolineum, imported from Germany, for a distance of two and one-half feet below what is known as the "air line" and one foot above. The poles are framed and cross armed so that the three wires of each three phase circuit form an equilateral triangle thirty-six inches on the side and forty-two inches on transpositions, each line being transposed every mile. This transposition consists of one-third of a turn or spiral, that in one line being to the right, while that of the other is to the left. In other pole lines it has been found that although the pins may have been amply separated for straight line work, the twisting of the lines at the transpositions brought them so near together at the center of the transposition span that they have been shortened even by such small birds as meadow larks. This occurrence has been avoided in the lines under consideration by making the sides of the triangle six inches greater on transposition



EIGHT MEN ARE ALL THAT ARE REQUIRED TO RAISE A 60-FOOT POLE.

(Continued on page 198.)

*Submitted for discussion at the Fifth Annual Convention of the Pacific Coast Electric Transmission Association, San Jose, Cal., June 18-19, 1901.

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EDITORIAL.

THE ASSOCIATION PAPERS.

When one looks over the engineering literature that has been published concerning the transmission of electrical energy as practiced in the various countries of the world, he becomes impressed with the fact that little or nothing has been written regarding the practical side of the construction of polelines designed to carry the heavy cables now used in extremely high potential and extremely long distance transmission service. It is my conviction that the poleline is today the most vital portion of any transmission, and this belief is held for reasons which must be clear: all other portions of the system are in duplicate, and these duplicate parts are run in parallel and generally underloaded, so that if one device breaks down the remaining devices in service are abundantly able to carry the load, or even the overload, until another spare device has been cut in to take the place of the crippled member. Generators, transformers, exciters, water wheels, pipe lines and all the mechanical and electrical features of the power house and substations are laid out with this one idea in view, namely, a reserve unit always stands in readiness to be cut in for instant service at times of emergency.

More than this, every piece of machinery in every station is under the direct supervision of skilled attendants, who instantly and intuitively detect the slightest symptom of derangement and, rushing in where laymen fear to tread, promptly prevent disaster at all times. The power house is thus always being operated under ideal conditions, so far as external interference is concerned; but as for the poleline, it catches figurative thunder, also literal lightning, and rain, and snow, and sleet, and bugs, and birds, and washouts, and felonious bullets, and, in truth, every injury which natural causes or evil ingenuity may devise. Poleline inspection, however thorough, is at best but superficial, and the line, when once finished, is to all practical intents and purposes, left to shift for itself with no paternal care forever guarding it. Its lot is, therefore, directly opposite to that of the machinery of the power house, which is given every shelter and protection and is always under competent surveillance.

A study of the relations existing between the power house machinery and the poleline shows quickly why it is that the construction of the latter should receive every care and attention that it is possible for the human brain and hand to bestow upon it. The line, reaching over hundreds of miles of every kind of country, and liable to injury from countless causes, must remain intact under penalty of a discontinuance of service, but if a generator or a water wheel or a transformer of the Bay Counties Power Company's system gets into trouble, why, what of it? The consumer will never know it; his service will go on uninterruptedly and the worst that can happen will be that the station attendants will get an unexpected "move on" for the few brief minutes required to bring relief to the disabled unit.

It is very evident to one who reads the two invaluable papers on the features of construction of the pole lines of the Standard Electric and Bay Counties systems, appearing in this issue, that these ideas have been ever uppermost in the minds of the two engineers who have written them. Both are masters of their art, and these articles may be accepted without qualification as representative of the most modern ideas of the era. The problem has been, in a measure, attacked from different standpoints, and while it is probable that the engineer will evince greater interest in the Bay Counties system because of the great Carquinez span and the double poleline, the fact must not be lost sight of that the Standard Electric poleline is, too, a marvellous exhibition of engineering skill and ability.

It should be added, perhaps apologetically, that the infinite importance of the subject of poleline construction is ample warrant for any seeming redundancy which may be deemed by some to exist for again making it the theme of extended editorial consideration. The cold, hard fact of the matter is this: while some portions of a great transmission system may properly be regarded as channels for the exercise of economy during the construction period, the poleline is certainly not to be regarded as such, for it represents the nerves of the system, without health in which the entire installation becomes a hopeless paralytic, at best capable of but erratic duty.

An interesting bit of testimony bearing upon the experiment successfully tried and since adopted by the Bay Counties Power Company, in which the telephone line between the Colgate power house and the Oakland substation is run on one of the polelines carrying the 40,000-volt, 132-mile power circuit straight—that is, without transposition in the telephone circuit—is furnished in an able article by Mr. Enrico Bignami, a prominent engineer of Italy, contributed to the current issue of *The Engineering Magazine**, describing the great electrical installations of that country. In discussing the features of the poleline of the Paderno-Milan transmission line, Mr. Bignami states that he can do no better than to quote the report of

*Volume XXI, Page 711.

Signor Guido Semenza, one of the engineers and directors of the Italian Edison Company, upon the subject of telephone circuits on power transmission polelines. This report states:

"Considerations of economy and convenience of inspection frequently lead to the erection of the telephone line on the same poles with the transmission wires. At the outset of our exploitation we concluded that induction would cause such noises in this case as to disturb or even forbid telephonic communication. The remedy, however, is very easy to apply when the true causes of the disturbance are understood.

"I feel justified in saying that the noises disturbing the telephone are caused by electrostatic induction. In our case, at least, electromagnetic induction gives no trouble. Our telephone circuits are not transposed or spiralled. Nothing has been done to counteract electromagnetic induction, nevertheless the noise has been almost entirely suppressed by very carefully insulating all parts of the telephone circuit from the ground."

This was the contention made by Mr. Theberath before the San Jose Convention in support of his conviction that non-transposed and adequately insulated telephone circuits will give the nearest approach to perfect telephone service over circuits run on long distance high-tension polelines. A confirmation of his much-disputed beliefs has thus come from an unexpected quarter, and more than that, the incident shows how it is that ofttimes engineering minds, though at the earth's antipodes, will focalize in a common channel.

The Paderno-Milan transmission line is carried on handsome and strong structural iron poles set in pairs, a little less than seven feet apart, with an interval of 197 feet between pairs. The generators at Paderno each deliver 2000 horsepower to line direct in the form of 15,000-volt three-phase current, and, in discussing the line, Mr. Bignami's article refers to the curious fears and doubts expressed when the use of metallic poles was determined upon. It was said that it would be dangerous to touch the poles and that the presence of these conducting bodies in the magnetic field surrounding the live wires would augment the self-induction of the circuit and increase the energy losses. On the other hand a comparison of the depreciation costs of wood and iron poles showed a difference in favor of the wooden poles, but this was more than offset by the advantages of the iron supports—these advantages being greater safety and strength with a consequent reduction of the number of poles necessary, carrying with it an equivalent reduction in the number of insulators. This, it was held, combined economy with a lessening of the number of points of weakness in the line.

Practice has demonstrated that the danger to persons touching the iron poles of the Padermo-Milan line is, of course, absolutely without existence, and that the alarm felt on other grounds was equally without foundation. For instance, service interruptions due to storms since the operations were begun in 1898, have been but four in number, of which two were attributable to bad working of the lightning arresters which held the arc. After the two instances referred to, which occurred in 1899, the number of air gaps in series with each Wurts arrester was increased from 42 to 50 since which there has been no further trouble. Despite the violence of the storms and the fact that hail is the cause of frequent devastations, the number of discharges of the lightning arresters has been very small, rarely exceeding four or five during a single storm. "Does this fact depend on local conditions," asks Mr. Bignami, "or do the iron poles play a protecting role?"

Such a question as that which Mr. Bignami has asked is hard to answer, for the truth is that our knowledge upon the subject of atmospheric electricity is very superficial. That it is vital to learn more in this direction is patent, and so Professor McAdie, who has fullest realization of the importance of the subject, has endeavored during two Transmission Association conventions now, to awaken permanent interest in the study of the electrical phenomena of the atmosphere. His present paper* is of an elementary trend—something which, it is hoped, will kindle an ambition on the part of transmission engineers toward making investigations into, and records of, the static and lightning effects upon these exceedingly long aerial lines. Incidentally, Professor McAdie refers to matters having a bearing upon the all-momentous question of water supply, and in doing so he evinces perspicuity in the two directions that are perhaps less thought of, yet are really of more consequence than any within the realm of theoretical research into the causes which contribute to the welfare of continuity in electric transmission service. Other and less elementary papers upon the same subjects are promised by the same eminent author, and the manager or engineer who has transmission interests at stake will do well to prepare himself for their coming by making himself capable of digesting them thoroughly when they do appear.

Reverting again to the subject of telephone circuits on power transmission polelines, some light on the question may be gleaned from the article contributed by Mr. Frank P. Medina, appearing on page 207 of this issue. Mr. Medina, who is eminent among the telegraph engineers of America, tackles that which is virtually the same problem, yet from the standpoint of telegraphy, and he, too, has reached the conclusion that electro-magnetic induction is not so potent a mischief-maker as electro-static induction. Mr. Medina writes as he talks—most pleasingly and most convincingly—and his article discusses this "lateral induction," as he aptly terms it, in a very satisfactory way—so satisfactorily indeed, that the telephone and the transmission engineer who would achieve silent telephonic service over long transmission polelines, will at once feel that much information of advantage concerning transmission-telephony (if it may be so called) may be gathered from the study of the lateral induction effects occurring on the infinitely slower signalling utilized in long distance telegraphy. For instance, Mr. Medina shows, in a practical way, that lateral induction becomes a mischief-maker in telephony mainly during the brief interval of time when neither marking nor spacing current is flowing. Perhaps the seat of disturbance in transmission-telephony rests in a common cause with that of lateral induction in telegraphy.

*To appear in the ensuing issue of THE JOURNAL.

BAY COUNTIES TRANSMISSION LINE.

(*Continued from page 195.*)

arms than on ordinary runs, which brings the minimum separation between transposition poles down to thirty-

THE DOUBLE POLELINE ENDS AT THE BERKELEY-OAKLAND CITY LIMITS.

6 inches. The poles are of Oregon cedar, round, and in length as follows:

HEIGHT.	TOP.	BUTT.	DEPTH IN GROUND.
25 feet	8 x8	12x12	5 feet
40 feet	9 x9	14x14	6 feet
45 feet	10x10	15x15	6½ feet
50 feet	11x11	16x16	7½ feet
60 feet	12x12	18x18	8 feet

Referring to the map of the transmission lines of the Bay Counties Power Company, it will be seen that these lines parallel the railroad only between Cordelia and Davisville, a distance of thirty-three miles, so that by far the greater portion of the line construction was over country that could only be reached by team, and which varied in altitude from practically the sea level to something over 1200 feet, all of it above Arcade being mountainous, while that below Sacramento is over level country until Cordelia is reached, when mountains of varying altitudes up to 1000 feet are crossed before the line reaches Oakland. The extremes of temperature to which the lines are subjected vary from about 26 to 116 degrees.

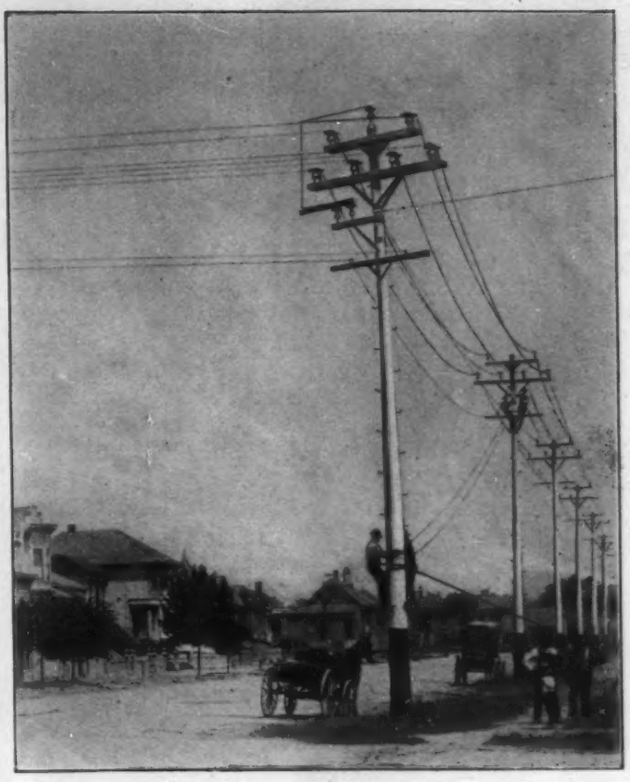
The poles are taken from the cars and placed on skidways convenient to frame and again loaded on wagons. This is done by the use of spike skids, a running line a snatch team and one man. This equipment is all that is necessary to load any kind of a pole on to any wagon. The poles are taken along the pole line and delivered with the top up hill and the butt of the pole at the hole, which proceedure does away with the handling of a pole the second time. After the cross arm is put on and the pins are nailed in, the pole is ready to set. This is done in three lifts by 8 men who are trained to work together and who pike and tamp-in 40 poles per day. As stated, most of the lines are over a mountainous country altogether inaccessible to a truck derrick, and the skill which the men have acquired in piking-in poles has become so remarkable that my preference is most decidedly for piking rather than derricking. In piking each man knows his position and he does his work with mechanical precision without a word being said or a motion made. In the first lift the pole is placed on to a six-foot deadman, as the short crosshorse is termed; in the second lift the pole is raised by the short pike men, while the third lift puts it into the hole, when it is caught by two long sixteen-foot pikes, one on each side, while in the vertical position. Then the two fourteen-foot pike men walk around to the sides of the pole and stay it so that by the time the "straw boss" has reached the butt of the next pole to sight the line, the short pike man is off to the side at right angles to the line, when the pole is finally set by the plumb bob and tamped-in.

Pole hole digging is one of the most important portions of line construction, and it forms a trade by itself which few become proficient in. All pole positions are "spotted" by one man, who does no other work. He carries a pick and shovel and digs a hole about a foot deep on the exact spot indicated by the surveyor's stake, the diameter of the hole being greater than that of the pole at the ground line by sufficient space to admit the use of a four-inch tamp bar. It is of the greatest importance that the pole holes should be uniform in shape, and especially is this true if soft ground is being worked. Practically all the holes were "shot," that is, blasted out, for in general the character of the ground worked was

AT LORIN MAY BE SEEN A TRANSPOSITION AND A RAILROAD CROSSING.

either hard pan or hard or soft rock. Bearing these points in mind it is easy to see that the "powder monkey," to be proficient and economical in the use of powder, must be possessed of good judgment and great experience. In fact, it is astonishing to see how expert a "powder monkey" can become. After the hole has been spotted, he knows at a glance the character of ground that he is to shoot out; if it is hard pan or doby he uses an one-inch auger, if it is hard or soft rock, he uses a drill and hammer, drilling down from twenty-four to thirty inches. No. 2 Hercules giant powder is used in quantities varying from one-half to two and one-half sticks per hole, according to the character of the ground, and in shooting out a five-foot hole in the ordinary ground encountered, the amount of powder used and the position or method of its use is gaged so skillfully that the ground will be loosened to within two inches of the depth desired. Any remaining dirt is barred out, ten foot thirty-five-pound bars being used. Of course no definite statement of the number of holes a man can shoot in a day can be made for the reason that the character of the ground is altogether too varied to enable any estimate to be formed, but just enough hole diggers are used in a construction crew to keep ahead of the pole setters and wire gang, so that all of the work shall go ahead together. The setting of forty poles is regarded as a day's work for a crew, that is, a single crew must dig the holes, frame, set and string the wire on forty poles under ordinary conditions, and this crew will consist of one hole spotter, two "powder monkeys" with sufficient hole diggers behind them to keep clear of the pole crew, eight men in the pole crew, five climbers, two reel men and two men on the blocks.

The main line consists, as stated, of two pole lines, one of which carries No. 00 B. & S. gage medium hard drawn copper and the other carries No. 0000 seven strand aluminum—the equivalent of No. 00 copper. Joints in the copper lines are of the Western Union type with nine

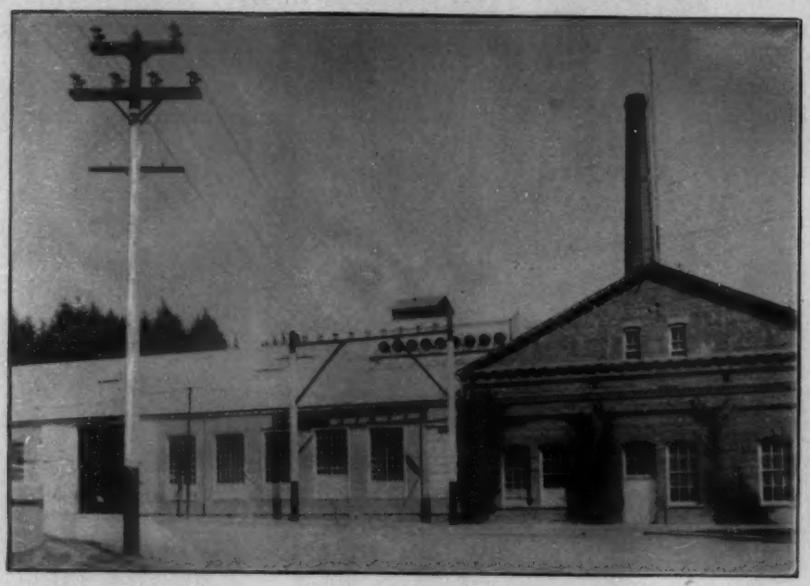


HEAD AND STRAIN GUYING A LIVE 40,000-VOLT LINE.

wraps on the side and an inch neck, soldered the entire length. Joints in the aluminum line are of the standard form, consisting of a right and left hand-scew conical shaped joint with the center or core wire of the cable turned back upon itself and the joint being filled with solder after being set up tight. No wedge is used, as every function of the wedge is filled by turning back 1½ inches of the No. 4 core wire. A team of horses on a watch tackle were not able to pull this joint apart.

The copper runs about 1,400 feet to the coil, two such

A DOUBLE CORNER AT TWENTY-SEVENTH AND WEST STREETS, OAKLAND.



PIEDMONT SUB-STATION, OAKLAND, SHOWING METHOD OF ENTERING HIGH-TENSION LINES.

coils being placed on the reels, when the lines are drawn out by horses. Transpositions are laid out on the ground. All this is being done while the linemen are tying in the last stretch. Then when the linemen get up to where the blocks are, they put on the temporary head guy to hold the line up and the blocks are taken off and sent ahead. Then the line men raise the wire up on the crossarms by the heaving lines which they carry, while in the meantime the same team has gone on ahead and has been hitched on to the blocks. The other line wires are then pulled up together by the team through a set of equalizers on the blocks. The lines are pulled up taut and then dropped back through the equalizers until the proper drop or sag has been reached,—this sag being 18 inches in the valleys, 22 over the hills, and six inches more around angles than on the straight line. Due allowance from these figures is of course made for temperature variations. Head braces are used on all heavy angles to hold the corners, and double construction is used on all road and railroad crossings and angles. No metal is used in head, strain, or anchor guys except with at least thirty feet of wood insulation intervening between the line wires and the ground. All braces run to cross arms, and it has been demonstrated that while the pole will heave if pole braces are used one-third below the top of the pole, braces will not cause heaving of pole if placed at the cross arm.

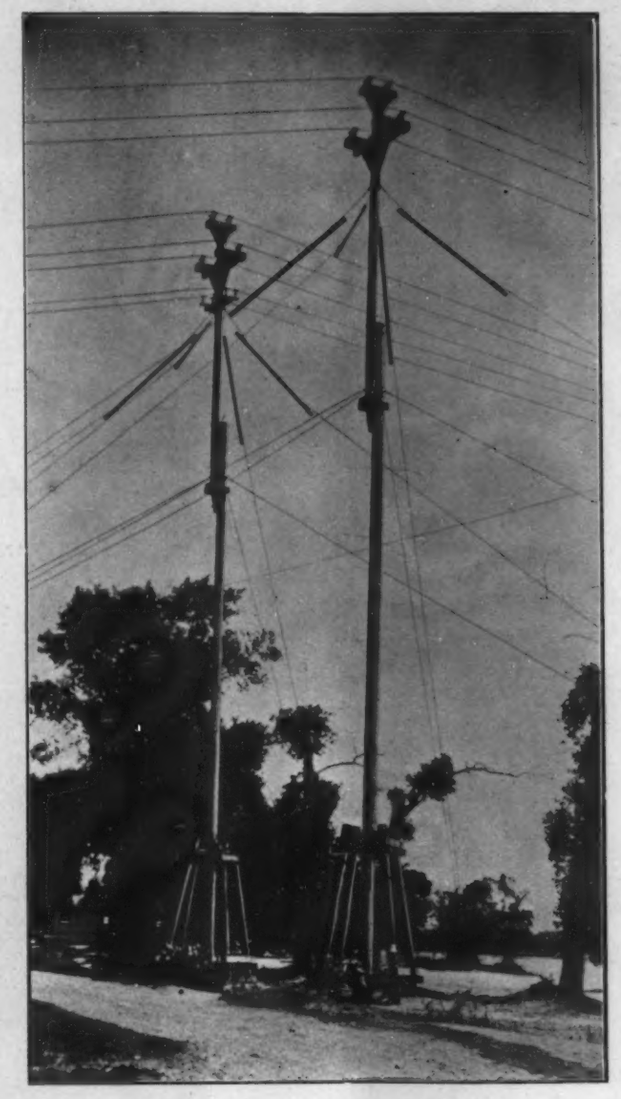
All changes in the elevation of the line are led up to by grading, and crossings over railroads clear the track by 42 feet to the transmission line. An aluminum stranded cable, No. 4 B. & S. gage, is placed on a cross arm 5 feet below the power arm of the copper line. This telephone line, which is not transposed, is supported on double petticoat deep groove glass insulators separated four feet.

Some notable spans, other than the one across the Straits of Carquinez, occur on the line, and the features of these are shown in the accompanying illustrations and drawings. At Vernon, in Yolo county, two spliced masts, 125 feet high, carry the lines across the Sacramento river in a span of 800 feet. No. 00 hard drawn copper is used for making the span, and the distinguishing feature of the masts are the 20 foot sticks of Oregon pine, 6 inches square, that are inserted in the guy lines for insulation purposes. The span wires run in trunnions of lignum vitae, supported on insulator tops, as shown in the drawing. The grading in the lines from these masts is a nice piece of work. The lines are carried down first to a 60-foot pole carrying a double "buck" arm which in turn supports a transverse arm carrying four standard pins and insulators, all placed in line and to which the line wires are tied. Next follow in succession 50-foot, 45-foot, 40-foot and 35-foot poles each similar to the 60-foot pole so far as the cross arm arrangement is concerned, but the 50-foot pole carries three insulators,

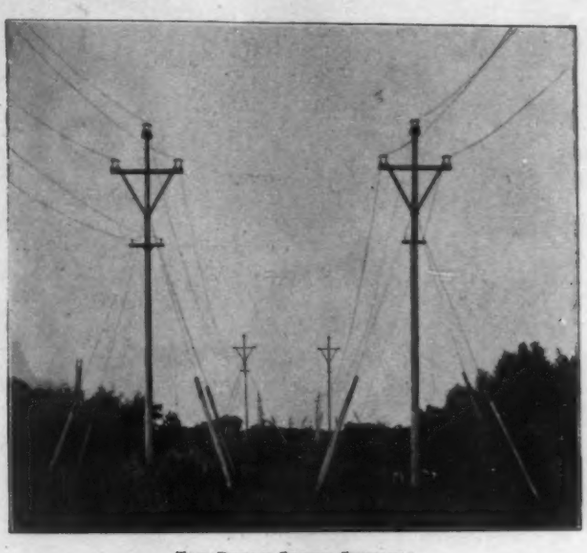
TWO CORNERS, WITH 60-FOOT SQUARE POLES, ON THE STANDARD TIE LINE.

while the 45-foot pole as well as the others, carry two insulators all on double arms. This arrangement gives ample anchorage. The clearance of this span is 85 feet and its sag is 27 feet.

Another notable span is that crossing the Putah Creek, more commonly known as the Davisville Canal, near Davisville. Its details are shown so fully in the accompanying drawings that further explanation is unnecessary. In fact, it seems almost idle to add any explanatory words concerning the features of Bay Counties pole line construction which the accompanying engravings illustrate. The double pole line continues through from Colgate to the North Tower, where the circuits are thrown together and then carried across the great Carquinez span* as a single three-wire three phase circuit, to the South tower, whence a double pole line is continued through to the city limits between Berkeley and Oakland. The style of transposition used is illustrated in the Grove street, Berkeley and the Lorin views, and

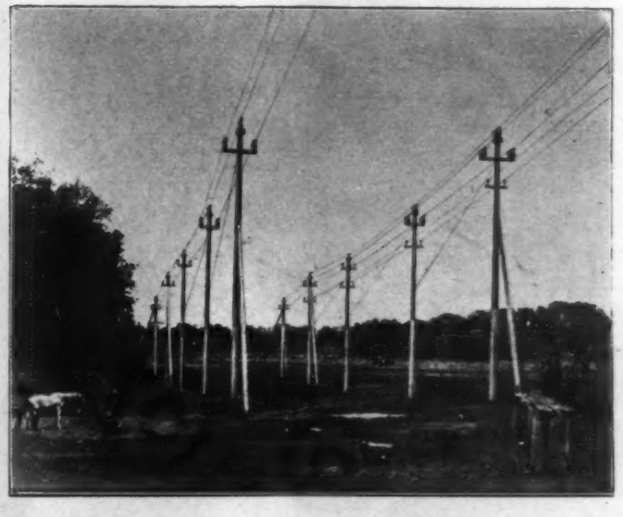


CROSSING THE FEATHER RIVER AT VERONA.



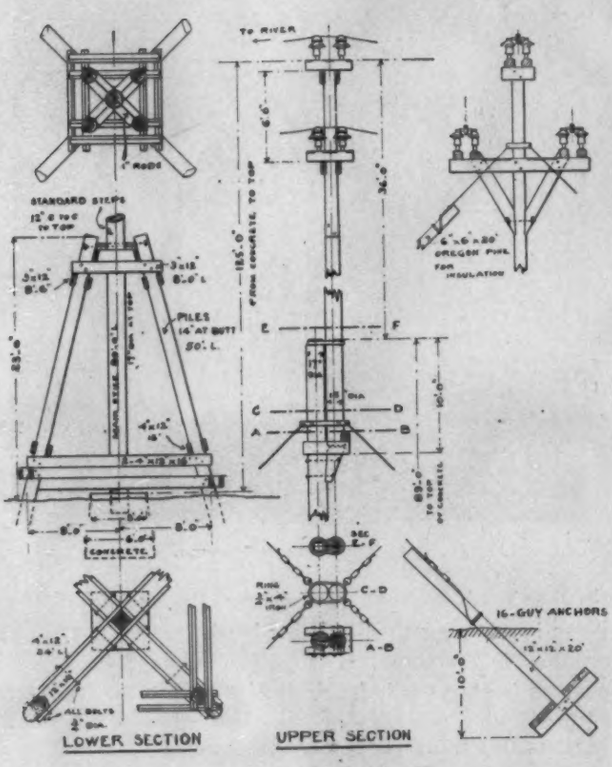
THE PUTAH CREEK CROSSING.

the Lorin photograph also shows the use of 60-foot poles in crossing the Berkeley local track of the Southern Pacific Company. The method adopted for bracing corners is shown admirably in the view of the terminus of the double pole line and the beginning of the single pole line. Where poles are placed at angles in the line, the possibility of trouble arising from any line pulling off its insulator, is believed to have been precluded through the use of "safeties," as may be seen in four of the engravings. These "safeties" consist of one-half-inch gas pipe bent around the circuit in the direction of pole in the manner shown, the ends of the gas pipe being secured to the tops of standard Locke high tension insulators, one of which is mounted on the top of the pole, and the remaining two at the lower end of the safety, being mounted in a special cross arm. It is about a mile through the city of Oakland from the Piedmont sub-station to the Grove street sub-station of the Standard Electric Company of California, and these two sub-stations are tied in by means of a single pole line of square sawed redwood poles, sixty feet in height and



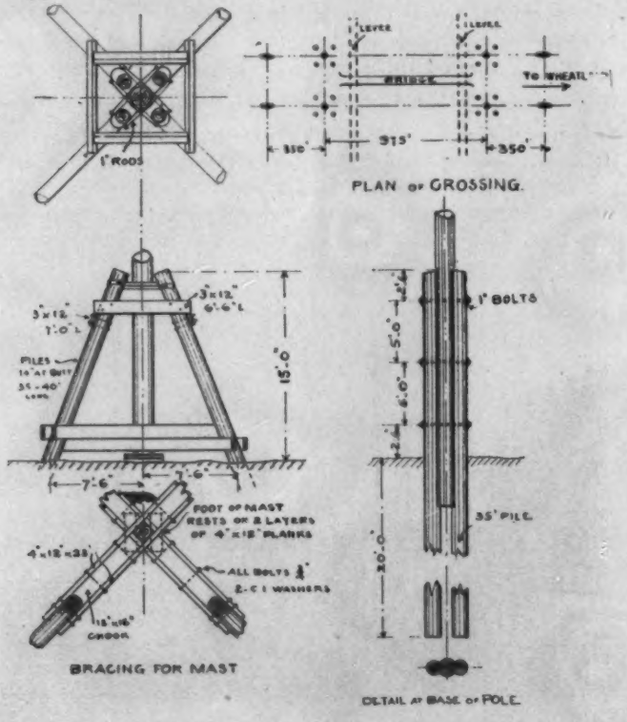
LOOKING NORTH FROM VERONA MASTS.

*Described in THE JOURNAL for May, 1901, Volume XI, page 91, *et seq.*

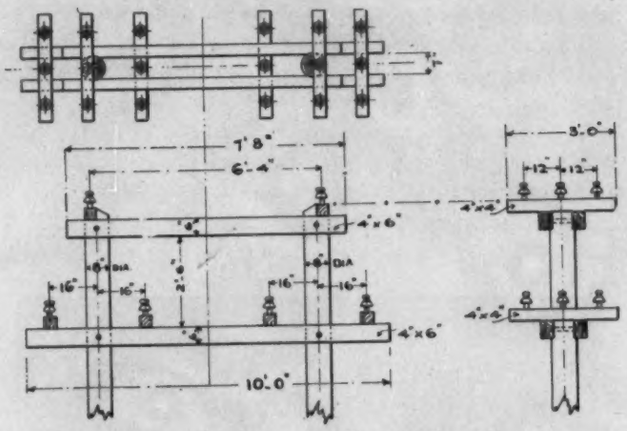


DETAIL OF MAST ON SACRAMENTO RIVER, AT VERNON.

carrying a single 40,000 volt three-phase circuit. The six-power cables from Colgate enter the Piedmont sub-station through the six terra cotta sewer pipes toward the left of the view of the Piedmont station, on page 170 of the last issue, and the three tie-in lines to the Standard sub-station come out through the remaining three terra cotta pipes—all through the intervention of a framing supporting double insulators.

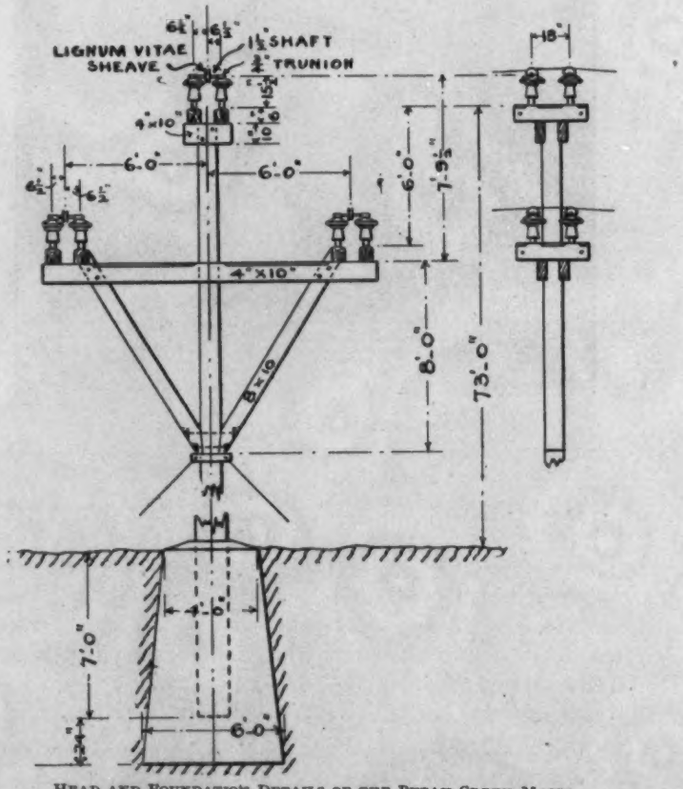


DETAILS OF CABLE CROSSING AT BEAR RIVER.



DETAILS OF THE FRAMING AT THE FEATHER RIVER CROSSING.

One other photograph deserves special consideration, and that is the one illustrating a crew of men placing head and strain guys on 50-foot poles in Oakland, while the transmission line is carrying 40,000 volts in regular service and while the telephone cables are altogether too "hot" for physical comfort. In this work, the men work in pairs, and each man uses but one hand, so that the pair of two men really perform but one man's work. Added safety is thus secured, but I assure you that the sensations experienced by these men working with their hair constantly standing bolt upright, in frenzied response to the commands of the static charge of the line, is not altogether comparable to the delectations possible from the mingled combination of an inviting shade, a long iced drink and a red-hot summer's day.



HEAD AND FOUNDATION DETAILS OF THE PUTAH CREEK MASTS.

Gas

INDUSTRIAL GAS.—XX.

BY FRANK H. BATES.

SPECIAL DIRECTIONS FOR EXAMINATIONS OF PETROLEUMS.

HAVE the petroleum in a one-ounce flask which is fitted with a perforated cork stopper and medicine dropper. Weigh the whole, remove thirty-five drops by means of the dropper and weigh again. In this way test the dropper until you have determined how many drops are required to make a weight of about ⅓ gram of oil. This is about the correct amount to use when crude petroleums and heavy mineral oils are tested, but when lighter oils, such as gasoline and kerosene, are tested, use only about 0.1400 gram of the oil.

Prepare some very finely pulverized pure cane sugar, dry in the oven at 105–110° C. for one hour. Weigh exactly 0.5000 gram upon a carefully counterpoised watch glass; transfer about one-half of a measure full of chemical to the cartridge, and the 0.5000 gram sugar, also 6 grams of the *special chemical*, and last the other half measure of chemical; shake well and proceed with the combustion as usual. Make several such determinations in order to obtain a good general average.

Having determined this blank carefully, it can be used in all the tests to be conducted on petroleums. Pour about one-half of 6 grams of the *special chemical* into the glass mortar, then drop on the surface the required amount of petroleum from the weighed container. Now add exactly 0.5000 gram sugar (dried and finely pulverized), also the remainder of the special chemical and triturate thoroughly until the mixture is uniform in appearance. Now pour one measure of chemical into the cartridge, transfer the mixture from the mortar and pestle into the cartridge, add an additional half measure of chemical, screw on the top of the cartridge and shake thoroughly for about three minutes. Next tap the sides, bottom and top of the cartridge well; put on the spring clips with vanes; place in the can containing 2 liters of water (the temperature of the water being about 4° F. below the room temperature), stir for five minutes in the same way as when testing coal. Now weigh the flask with dropper again, the loss gives the amount of oil taken. Take the readings and ignite in the same way as when testing coal.

LINEMEN WHO WOULD TIE-IN THE LIVE THUNDERBOLTS OF JOVE, IF NECESSARY.

The men who have the hardihood to perform the line work which Mr. Dutcher's article refers to are worthy of especial mention, for surely they are each and all possessed of the very personification of grit. In the illustration above Mr. Dutcher stands at the extreme right in a pose which will be recognized as characteristic. Next to him stands H. Worthington, foreman of the crew; then follow consecutively Ed. Briody, Dan Graham, Wm. Smart and "Kid" Langdan, while in sitting postures are Charles Blum (with "spurs" on), Matt Calvin and Wm. Brown.

If lighter oils (kerosene and gasoline are examined) the transferring and weighing must be done as rapidly as possible. Also, instead of mixing in a mortar proceed as follows: Mix the 0.5000 gram of sugar (dry, finely ground), 6 grams *special chemical* and one and one-half measures of chemical in the cartridge by shaking thoroughly. Now remove about one-half of the mixture, drop about 0.1400 gram of the oil into the cartridge, allowing the drops to fall on various places of the surface of the mixture, again return the mixture to the cartridge and without shaking proceed with the test as usual.

Calculation. R_1 = rise due to sugar + wire as determined by the preliminary tests.

R_2 = total rise when burning oil.

W = weight of oil taken.

$$\frac{(R_2 - R_1)\ 2123.5}{W} \times 0.73 = \text{B. T. U. per lb. of oil.}$$

The following oil determinations serve to show comparative results as obtained by the Parr and Mahler Calorimeters:

BY PARR CALORIMETER.

OIL.	W.	E.	R_2	R_1	CALORIES.	AVER'GE IN B. T. U. PER LB.
Texas Petroleum.....	.3099	2000	3.967	1.715	10600.0	19160.
	.3335	2000	4.156	1.715	10685.0	19160.
Engine Lubricating..	.2514	1982	3.606	1.715	10860 0	19540.
	.2612	2000	3.662	1.715	10880.0	19540.
	.3254	2000	4.129	1.715	10830.0	19540.
Gasoline	.1382	2000	2.741	1.715	10838.	19580.
	.1413	2000	2.773	1.715	10924	19580.

W = weight of oil taken.

E = water + water equivalent of instrument.

R_2 = total rise in degrees centigrade.

R_1 = rise due to sugar in degrees centigrade.

$$\text{B. T. U. per pound} = \frac{(R_2 - R_1)\,E}{W} \times 0.73 \times 1.8$$

BY MAHLER CALORIMETER.

OIL.	W.	E.	R.	C.	RESULT IN CALORIES.	AV. IN B. T. U. PER POUND.
Texas Petroleum	.3100	2355	1.415	22	10678.	19160
	.3442	2355	1.562	16	10618.	
Engine Lubricating....	.2976	2355	1.378	23	10824.	19440
	.3005	2355	1.376	23	10768.	
Gasoline....	.5600	2355	2.583	23	10821.	19480

W = weight of oil taken.

E = water taken + equivalent of instrument.

R = rise in degrees centigrade.

C = correction due to burning of iron wire given in calories.

$$\text{B. T. U. per pound} \frac{[(R \times E) - C]}{W} \times 1.8.$$

(To be continued.)

Personal

CLAUDE ELMER DUTCHER, whose Transmission Association paper describing the practical features of construction of the transmission lines of the Bay Counties Power Company appears in this issue, is well qualified to write on the subject chosen, not only from the fact that he was the field engineer in actual charge of the work, but because of his long familiarity with heavy electrical construction, gained from an experience in that direction covering nearly twenty years. Born in Philadelphia on September 4, 1868, and reared in the family of his parents, he had every early advantage, for his father, Byron Mortimer Dutcher, was a prominent lawyer in that city a quarter of a century or so ago. His final schooling, however, was had in Detroit, Mich., where he graduated from the high school at the age of fourteen years. His already developed fondness for rough and ready work, coupled with a fascination of the science of electricity, with which he had been seized, led him to strike out at once into the activity of poleline construction work for the American Bell Telephone Company in the state of Michigan and thereabouts in the capacity of lineman. After climbing poles a year or more for the telephone company, he joined a construction crew of the St. Paul office of the Northwest Thomson-Houston Electric Company, in the erection of central stations, isolated plants and general installation and wiring duty. Next he went with the Edison General Electric Company as a construction foreman, in which capacity his work may be traced in all the principal cities from the Great Lakes to Puget Sound. Some four years altogether was spent in electric railway construction, and for two years or so he was engaged in this class of work in Montana alone. Then followed another two years as foreman during the building of the Great Northern railway in Montana, Idaho & Washington, and after its completion he again returned to electrical construction work, in which he has since remained exclusively. In addition to having installed electric plants throughout the great Northwest and the Pacific Coast, he has done similar work in Alaska, Mexico and Japan.

CLAUDE ELMER DUTCHER

Mr. Dutcher's California experience dates back to 1896, when he served a year as station operator for the San Joaquin Electric Company. He then located in San Francisco, and as constructing engineer he built the Fresno-Hanford extension of the San Joaquin Electric Company's Fresno transmission. He was engineer of the Comstock Pumping Association during its preparations and investigations preparatory to the closing of the contract with the Truckee General Electric Company for the delivery of electric power to the Comstock mines. He also contracted for the building of the poleline of the Truckee-Comstock transmission, after which he returned to San Francisco, whereupon he entered the employ of the Bay Counties Power Company for building the double main line of the Yuba-Oakland transmission within the territory lying between the Sacramento river and the terminus of the line in the city of Oakland. Having finished the Bay Counties' lines, his services were at once secured by the California Central Gas and Electric Company for superintending the building of its high-tension polelines for the distribution of Bay Counties' power throughout Napa, Sonoma and Marin counties.

Mr. Dutcher is not a man who will permit physical comfort, or even physical welfare, for that matter, to stand in the way of the execution of business. He has earned the reputation of being indefatigable in his work — indeed, if he were to be criticised, it would be said that he works too hard and rests too little. Nevertheless he is undoubtedly one of the best construction foremen to be found in the West, and the manner in which he has supervised the erection of the Bay Counties' line must long stand as a monument to his skill. But few know Mr. Dutcher, in the fullest sense of the word, but those who do so know him are his staunchest friends.

CECIL B. SMITH, Mem. Can. Soc. C. E., assistant engineer, City Engineer's Department, Toronto, Canada, and formerly assistant professor of civil engineering, McGill University, and Wm. S. Aldrich, Mem. Am. Inst. E. E., Mem. Am. Soc. M. E., Professor of Electrical Engineering, University of Illinois, have opened an office as consulting engineers, rooms 101-103 Mail and Empire building, Toronto, Canada.

THE SPEED OF CENTRIFUGAL PUMPS.

An excellent authority* gives the following simple rule for finding the speed of a centrifugal pump for any given head: Multiply the square root of the head, in feet, by 500, and then add 500. This sum gives the circumferential speed of the pump-runner in feet per minute, and, by dividing it by the circumference of the runner, in feet, there will be found in the quotient the number of revolutions the pump must run per minute.

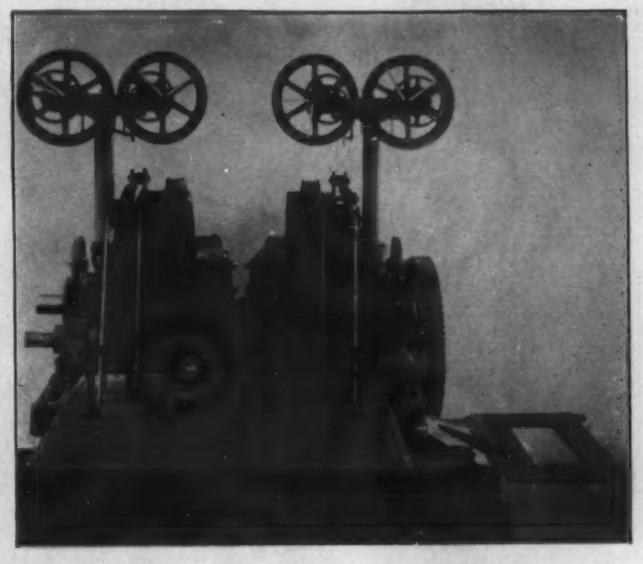
A "miners inch" of water is about equal to a supply of 12 United States gallons per minute.

*Risdon Iron Works Catalogue, No. 10, third edition, page 104.

ELECTRIC HOISTS ON THE COMSTOCK.

BY LEON M. HALL.

WITH the advent of electricity on the Comstock, it became necessary to take up the problem of hoisting from considerable depths by means of electrical energy and after much research and a thorough investigation of the then-existing electrical hoisting machinery, it was evident that in order to meet our conditions of service and power, there must be procured something radically different from the usual run of such machinery.



ELECTRIC HOISTS ON THE COMSTOCK.

The writer then, after discussing the matter with the Risdon Iron Works of San Francisco, decided on the system as illustrated in this article, the ultimate result being the development, installation and successful operation of a continuous rope electric hoist, driven by means of a variable speed, three-phase induction motor.

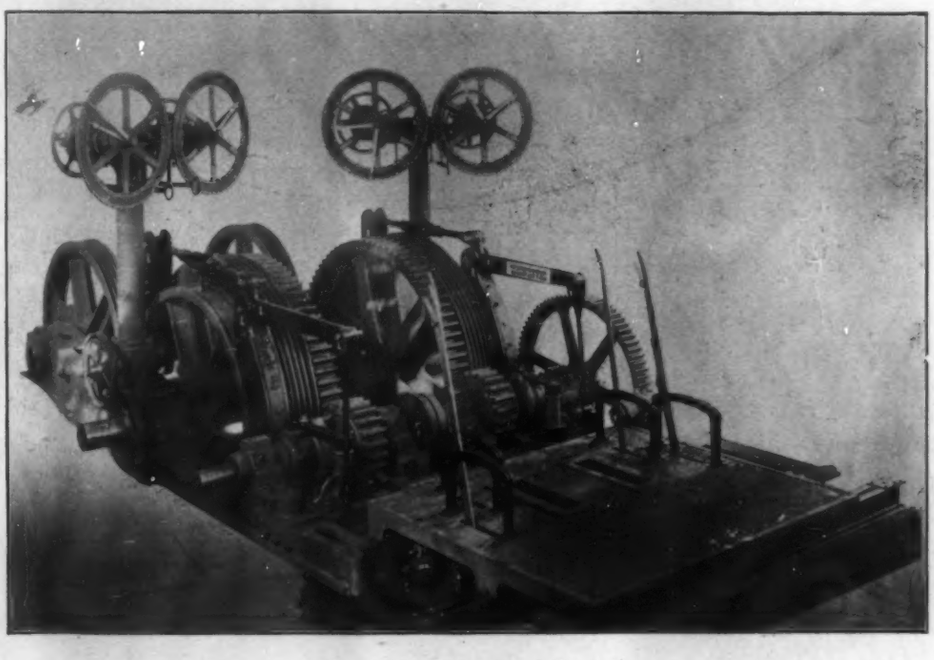
The power for the Comstock is developed on the Truckee river at a point near Floriston, thirty-three miles from the mines, in Storey county, Nevada, as has been so fully described in these columns heretofore.*

The generating station is equipped with two 750-kilowatt three-phase sixty-cycle Westinghouse generators, and six 300-kilowatt oil-cooled transformers. Turbines are used to drive the generators, and a close regulation is secured by means of automatic governors. At the station the potential is raised from 400 volts to 24,000 volts, at which pressure it is transmitted over a double circuit to the sub-station, in Virginia City, where the potential is reduced to 2300 volts, and in this form is distributed to the various mining companies. In the case of each hoist but one, namely that at the C. & C. shaft, it is again reduced to about 450 volts. The power is purchased of the Truckee River General Electric Company upon a continuous rate basis, the amount being fixed by a peak load of two minutes' duration. Under these conditions, it has, therefore, been the endeavor of the mining companies to secure a hoist that will operate at the highest possible efficiency and at the same time effect the regulation of the general system to as slight a degree as is consistent with good service.

To meet the condition of high efficiency, it is evident that the motor should operate continuously at or near its full load capacity and be designed especially for the work it has to perform. For a continuous full-load condition, the work must of necessity be constant at all points in the lift, and the nearest possible approach to this was secured by the adoption of the continuous rope or balanced system, where the load is reduced to the weight of the rock alone. Then to secure the necessary variations in speed an induction motor with a non-inductive resistance in both primary and secondary was developed—the resistance being varied by the introduction of a modified form of the ordinary street car controller. With an equipment of this kind the cages are started slowly and the dip in line voltage is comparatively slight, being about 7 per cent. at starting. By running on the second notch of the controller, one-third of the maximum speed may be maintained for the full length of the shaft.

The hoist itself, as will be observed in the accompanying photographs, consists essentially of a main driving drum and an idler, around which the rope is wrapped four times in order to secure the necessary friction for lifting. From the main driving drum, the rope is carried over the head sheave, down one compartment, under a movable tail sheave, back to the second compartment over a second head sheave and on to the driving drum. One cage is inserted between the ends of the cable and the other is fastened by means of heavy iron clamps, one above and one below the cage, in the adjacent compartment. This simple arrangement enables the operator to vary the relative position of the cages at pleasure, and also permits the use of one cage in a single compartment without reference to the other.

The hoist is necessarily a geared machine, the motor speed being reduced by the introduction of cut gearing. To the main drum is attached a brake ring upon which is operated a heavy post brake, which is set automatically by means of a heavy weight, and is released by hydraulic pressure. In the case of the Yellow Jacket and Belcher, there are two hoists side by side, both being operated by one motor. One of these is intended for the vertical shaft and the other for the incline, which leaves the vertical at the point where the vein intersects it. Double-deck cages are



ELECTRIC HOISTS ON THE COMSTOCK.

*THE JOURNAL, Volume X, page 95, November, 1900.

used in each compartment of the vertical shafts and a two-ton self-dumping giraffe is placed in each compartment of the inclines. The hoists have been erected in the most substantial manner upon concrete foundations, which has resulted in there being practically no vibration and very little noise.

The following table will give complete data upon each of the four installations:

KIND OF HOIST.	Yellow Jacket G. & S. Mg. Co.	Belcher Silver Mg. Co.	Union Shaft Co.	Con Cal. & Vir. Mg. Co.
	Double continuous Rope Hoist for 4 Compartments.		Single Continuous Rope Hoist for 2 Compartments.	
Daily capacity from bottom	500 tons	500 tons	500 tons	600 tons
Make of motor	Gen. Elect.	Gen. Elect.	Gen. Elect.	Westinghouse
Type of motor	M 7200 alternations	M 7200 alternations	M 7200 alternations	F 7200 alternations
Electromotive force	440 volts	440 volts	440 volts	2240 volts
Size of motor	75 H. P.	75 H. P.	100 H. P.	300 H. P.
Speed of motor	450 R. P. M.	450 R. P. M.	450 R. P. M.	550 R. P. M.
Weight of rock	3200 lbs.	3200 lbs.	3200 lbs.	3760 lbs.
" double-deck cage	2200 lbs.	2200 lbs.	2100 lbs.	2951 lbs.
" two cars (max.)	1700 lbs.	1700 lbs.	1700 lbs.	1730 lbs.
" rope in each shaft	1896 lbs.	1390 lbs.	2528 lbs	5000 lbs.
" total load raised	8996 lbs.	8490 lbs.	9528 lbs.	13,441 lbs.
" unbalanced load	3200 lbs.	3200 lbs.	3200 lbs.	3760 lbs.
Diameter plow steel rope used	1 in.	1 in.	1 in.	1 1-8 in.
Weight of rope per foot	1.58 lbs.	1.58 lbs.	1.58 lbs.	2 lbs.
Distance load to be hoisted	1175 ft.	850 ft.	1550 ft.	2500 ft.
Max. rope speed per minute	600 ft.	600 ft.	750 ft.	1250 ft.
Weight of incline car	2000 lbs.	2000 lbs.	.....	.....
Weight of rock	4000 lbs.	4000 lbs.	.....	.....
Length of incline rope from sheave	1500 ft.	1350 lbs.	.....	.....
Size of incline rope	1 in.	1 in.	No inclines	No inclines.
Length of incline	400 ft.	550 ft.	.....	.....
Size of each compartment	5 ft. x 7 ft.	5 ft. x 7 ft.	.....	.....
Unbalanced load on incline	4000 lbs.	4000 lbs.	.....	.....
Max. rope speed per minute	600 ft.	600 ft.	.....	.....
Angle of inclination	45 deg.	36 deg.	.....	.....

In each of the foregoing the continuous rope or balanced system has been adopted and the actual load lifted amounts to the weight of the rock alone, plus the friction losses. The load is constant at all points in the lift, and the strain upon the mechanism is equalized at all times except when starting and stopping.

The Yellow Jacket hoist was a success from the start and was operated for more than a month with a single cage in one compartment. This is the severest test to which the hoist can be subjected and under these conditions the performance is as near perfection as any hoist I have ever seen. Tests were made during this time and the following are the results:

Weight of cage	1200 lbs.
Weight of car	850 lbs.
Weight of rock	1600 lbs.
Total weight lifted	3650 lbs.

Maximum rope speed 600 feet per minute.

Length of vertical lift 1175 feet.

Time of hoisting 2 minutes, 10 seconds from the moment the load was started until cage was landed on chairs, at the surface.

Time to accelerate load 8 seconds.

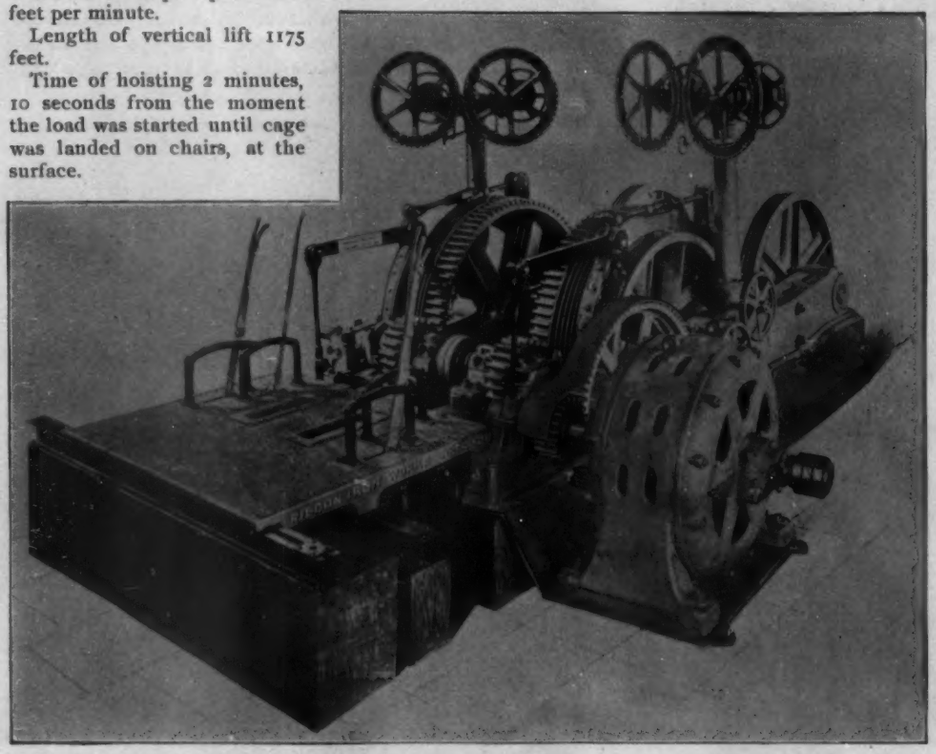
Power required, as per wattmeter readings, was 88.40 horsepower.

Theoretical power required, 66.40 horsepower.

The efficiency of the system is, therefore, about 75 per cent., and this includes the motor and all friction losses from the secondary of the transformers. The secondary voltage was 525 volts before starting and the running voltage was slightly over 500. The maximum current per phase at starting was 180 amperes and 85 amperes when operating at full load. A reading was also taken while lifting the empty cage at 600 feet per minute and the wattmeter showed 48 horsepower. It will, therefore, be seen that the results obtained are remarkably good and no trouble should be experienced with a hoist of this character upon any well regulated plant. At a future date I will take pleasure in submitting data when these hoists are operated under balanced conditions.

In conclusion I will add that the successful operation of this hoist is a decided advance in mine hoisting—not alone in the high efficiency secured, but also in its large capacity as compared with the size of the motor in use. Of course there are cases to which this system is not adapted, but wherever it is applicable, it is certainly worthy of serious consideration where economical operation is a feature of the development.

All four of the hoists* were built by the Risdon Iron Works of San Francisco, which publishes a pamphlet with controller and torque diagram, which will interest anyone interested in mine hoisting. All four hoists are built so that the speed can be doubled, using two motors instead of one, thereby giving twice the capacity named in the table.



ELECTRIC HOISTS ON THE COMSTOCK.

Technical trade literature is fast assuming an importance that is equalled only by the truly artistic manner of its production, yet it is noteworthy that the publications which have appeared heretofore have been brought out only by Eastern concerns. Now, however, a departure from this rule must be noted, for the 1901 catalogue of the Pelton Water Wheel Company has set a new pace which Pacific Coast manufacturers must keep abreast of, or be regarded as non-progressive. It consists of sixty-four pages, in standard catalogue size, every single one of which is invaluable to transmission engineers.

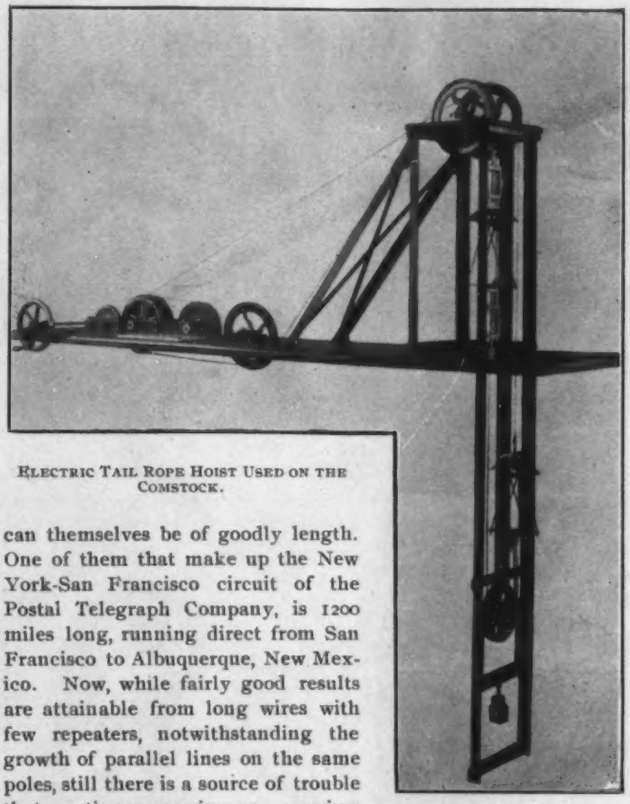
*See opposite page for illustration of model of electric tail rope hoist.

LATERAL INDUCTION AND THE TELEGRAPH.

BY FRANK P. MEDINA.

THE most striking characteristic in the growth of telegraph plants in recent years is, perhaps, the tendency to work direct circuits between points more and more distant from each other. The attempt to work such circuits as those between Chicago and San Francisco, which are now worked every day, was, a few years ago, looked upon as useless. But today New York and San Francisco are directly connected with each other by duplex systems which yield very good results.

Of course these long circuits are compound in their nature; that is, they consist of component circuits added together through repeaters. Where the parallel wires are few, and far apart on the cross-arms, the compound circuits work well with few repeaters. Under these slimed working conditions, the component circuits



ELECTRIC TAIL ROPE HOIST USED ON THE COMSTOCK.

can themselves be of goodly length. One of them that make up the New York-San Francisco circuit of the Postal Telegraph Company, is 1200 miles long, running direct from San Francisco to Albuquerque, New Mexico. Now, while fairly good results are attainable from long wires with few repeaters, notwithstanding the growth of parallel lines on the same poles, still there is a source of trouble that continues growing as new wires are added that causes the working to become more and more difficult. The cause of this trouble is the mutual action between the wires during the signaling process, and the effect is to shatter the signals by causing the relay levers to flutter, or by holding them back from responding to the signal-elements transmitted to them. The greater nearness of the wires to one another throughout their length is, of course, the reason for this increased interference between them.

Induction is the name given to the phenomenon that causes the trouble; mutual induction between wires. I am not able to get much satisfaction out of this name, for it appears to me to include phenomena so varied in character as to belong in different classes. But this is another story. Let us now distinguish between the mutual action which takes place between the primary and secondary coils of a transformer, and that which occurs between the two plates of a plane condenser. The former, or electro-magnetic induction, and the latter, or electro-static induction, both occur in the working of telegraph lines. Which of them is the more prominent in its effect? Do the inductive troubles between wires belong to the class of phenomena distinguished as electro-statical, or are they properly included under the head of electro-magnetic? Is the induction coil effect between these long wires the source of the shattered signals or are they due to the electro-static strain that manifests itself in a condenser? Notwithstanding the prevalence of the contrary view I believe the answer is that the electro-magnetic effect is usually negligible compared with the electro-static effect. Here is the fact pointing to that conclusion:

When an induction coil is operating, if the primary current is broken, the current in the secondary moves from end to end in the same direction, and a wire outside would carry the momentary impulse current throughout its length all in the same direction around the circuit. But there is no such effect manifested between long telegraph lines 16 or 18 inches apart. Substitute a condenser for the induction coil, but join it up so as to simulate the conditions obtaining between long parallel telegraph wires. This can be done in the case of a two-plate condenser, by attaching one of the plates to the middle of, say, a thousand-foot length of wire, and the other plate to another thousand-foot piece of wire. What happens when one of these wires is charged by a battery? The other wire is subjected to an inductive influence, but the current is no longer continuous around the circuit. In fact two currents flow away from the condenser in opposite directions along the second wire and tend to neutralize each other. Earthing the wires will make these two currents manifest.

Now this is exactly the effect that shows itself between two adjacent telegraph wires, and this is why I think our troubles come, not from the transformer effect between the wires, but from the condenser effect. A transformer effect would on closing circuit A produce a current in the same direction all along the line B. A condenser effect would produce a current that was moving, say, toward the distant station away from the point of maximum influence, and also a current toward the home station, away from the point of maximum influence, and this latter current, from the shorter route, would be very many times the stronger. This is because the point of maximum influence is close to the ends of the line, and the induced currents are strong in proportion to the shortness of their paths to earth.

Being statical in its nature this induction effect is a function of the electromotive force, and not a function of the current; so when it becomes necessary to decrease it, it has to be done by decreasing the electromotive force. This proposition, of course, implies that the placing of the wires farther apart is impracticable, for that is the real remedy indicated. There are two ways of accomplishing the design of reducing the electromotive force where a current of given maximum strength is used for signaling: using bigger wires or shorter wires. The former plan means the practical rebuilding of a plant, but the latter can be accomplished, still maintaining the total length of the compound circuit, by introducing more repeaters.

There are many strong reasons why these repeating stations should be as few as possible. Besides the extra running expense, there is always additional danger of apparatus trouble, and inattention of the attendant at any one of these points might destroy the usefulness of the whole line. Still there are reasons of greater moment which call for their establishment. Besides allowing a decreased electromotive force to supply component circuits, and thus diminishing the mutual static induction, the shorter circuit introduces a feature very valuable to clearness in signaling. To illustrate this let us examine the process of receiving a signal on a relay, by positive and negative currents.

Let us call the positive the marking current, and the negative the spacing current. With the spacing current flowing the relay lever rests on its back contact and the circuit of the local sounder is open. Now comes in the marking current, throws the relay lever over and closes the local circuit of the sounder. But just here is where the valuable feature of short circuit signaling comes in, where currents of a given strength are adopted for signaling purposes. In moving from the back to the front contact the lever is subjected to an interval of no pull either way—a moment when there is neither marking current nor spacing current, but a

state of vague neutrality. What a figure is cut by this interval of time that it takes the lever to pass from one contact to the other may be appreciated when it is stated that it is only during this interval that inductive interferences are usually felt. When the lever is under the influence of the marking current, or when spacing current is flowing, the induction is seldom strong enough to affect it. But the interval of lever movement from one contact to the other: this is the precious time; this is when the signals are mutilated by the action of adjacent wires. Now, by shortening the circuit, the time-constant is diminished and this interval of lever movement is cut down. The lever moves with greater rapidity and leaves less time for foreign influences to do their deadly work. It is obvious that if the lever could be made to move with infinite speed, mutual induction such as disturbs us now would not be felt at all. I do not think that this element of signaling the time of lever movement is sufficiently considered in telegraph practice. It explains why it is necessary to use greater current strength to work the same instruments on long circuits than on short ones which would appear to be unnecessary at first glance. Being an interval of lost time, it is always to be subtracted from the length of the marking current interval, or from the length of the spacing current interval, and, therefore, shows why, with the standard current for shorter circuits, signals on longer circuits will drop out some of their elements and cause others to stick together. If this movement-time of the relay lever were more intently regarded, there would cease to be used in certain classes of multiple telegraphs, relays with extra heavy levers and armatures, which can only increase this movement-time to the detriment of the signals.

Recent devices for transmitting double current signals depend on this principle of lever speed for their efficiency. The currents that operate them are large, the local circuit in which they are operated contains a very large proportion of non-inductive resistance to make its time constant small, and the levers are very, very light in weight. By this means, non-continuity preserving pole changers are made to simulate the effect of those that keep the points closed in reversing, thus obviating, in dynamo quads and duplexes, the necessity of using extra condensers and other cumbersome apparatus.

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

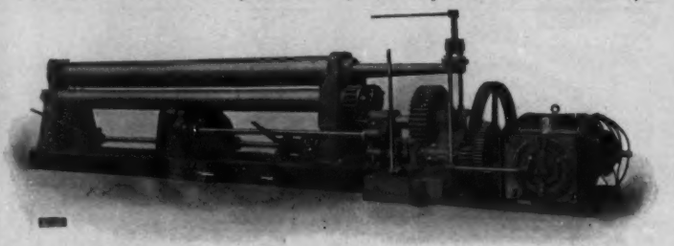
ELECTRICALLY DRIVEN BENDING ROLLS.

DIRECT-CURRENT motors directly connected to bending rolls constitute an application of electric power recently brought out by the Bullock Electric Manufacturing Company. In these equipments the rolls are solid wrought-iron forgings arranged in pyramid form, and have a capacity for bending plates up to twelve inches in width and five-eighths of an inch thick. The lower rolls are geared together while the upper or bending roll is revolved by the friction of the plate in passing through. It is adjustable by power to suit the thickness of the plate and the radius to which it is to be bent. It has a hinged bearing at one end which may be turned down out of the way, while the other end has a long shank extending to a third support which retains the roll in position for the removal of rings or flues. This will be found a great advantage in boiler and other shops where plates are to be bent to a complete circle. Midway between the housings a set of supporting rollers are placed to give additional stiffness to the lower rails, and for very long machines additional sets of rollers are added.

The machine is firmly tied together by a heavy cast-iron soleplate. It is strongly geared and all parts are made stiff and substantial. Levers and clutches are conveniently placed for the quick and easy control of all the operations. The machine is driven by an 18-horsepower, reversible, constant-speed, Bullock motor. For controlling the motor, an automatic rheostat is used to prevent the operator from throwing on the full current too quickly and burning out the motor.

The field consists of a circular yoke of special steel. While particular attention has been given to a reduction in weight, it has not been at the sacrifice of efficiency. The pole pieces, built up from soft sheet steel of the highest magnetic quality, are securely bolted to the yoke. The shape of the punchings is such as to produce a saturated pole face, and this feature, coupled with carefully proportioned windings, is largely responsible for the sparkless operation of the motor and is a feature greatly appreciated by engineers.

The field coils are machine wound and carefully insulated. The shunt and series coils of compound wound machines are separately wound. The coils are slipped over the pole before it is bolted to the yoke, and, should it be necessary, are readily removed. The armature core is built up from thin, carefully annealed sheet steel,



BULLOCK ELECTRICALLY-DRIVEN BENDING ROLLS.

possessing a high magnetic permeability. These disks are again annealed and then japanned. They are mounted upon the shaft and held firmly together by malleable iron end plates.

The windings, which are let into slots provided in the periphery of the armature core, are made of either copper bars or wire as best suits the requirements. The coils are machine formed, and after being formed are thoroughly insulated with mica and other high grade insulations. They are then baked in steam heated forms while under pressure, which removes all moisture and produces a perfect and very compact coil. The result is a coil that is less liable to be injured than when produced by the ordinary method and one which requires no further insulation when placed in position on the core. The coils of armatures are held in position by wedges of hard, thoroughly dried wood, driven into notches provided near the top of the slots.

The commutators are built from drop-forged bars of pure lake copper with selected mica insulation. They possess great durability and have an exceptionally even wearing surface for the brushes. The brush holder is simple and highly efficient, giving absolutely no trouble. It is of the reaction type; no adjustment of the brushes is necessary, and when they are once set the motor will operate in either direction without sparking and under all variations of load.

S. K. C. APPARATUS IN ELECTROLYTIC WORK.

One of the most notable of recent electrical contracts was awarded last month to the Stanley Electric Manufacturing Company of Pittsfield, Mass., by the Castner Electrolytic Alakli Co. of Niagara Falls, N. Y., for eight S. K. C. motor-generators, each set having a direct current output of 500 kilowatts. These machines will take the current from the Niagara Falls Power Co. at 2200 volts, 25 cycles, converting same into direct current of 245 volts for electrolytic work. The contract includes a complete switchboard equipment for handling the 8500 kilowatts.

TRADE LITERATURE.

"Interchangeable Arc Lamps" describes a form of lamp that can, by the easy changing of a few parts, be operated with equal facility on alternating or direct current, and on from 110 to 220-volt multiple service. It is of the enclosed arc type. *General Electric Company.*